Science, Service, Stewardship

2022 5-Year Review:
Summary & Evaluation of
Lower Columbia River Chinook Salmon
Columbia River Chum Salmon
Lower Columbia River Coho Salmon
Lower Columbia River Steelhead

National Marine Fisheries Service
West Coast Region

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5-Year Review: Lower Columbia River Species

Species Reviewed	Evolutionarily Significant Unit or Distinct Population Segment
Chinook Salmon (*Oncorhynchus tshawytscha*)	*Lower Columbia River Chinook Salmon*
Chum Salmon (*O. keta*)	*Columbia River Chum Salmon*
Coho Salmon (*O. kisutch*)	*Lower Columbia River Coho Salmon*
Steelhead (*O. mykiss*)	*Lower Columbia River Steelhead*

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1. General Information

1.1 Introduction

Many West Coast salmon and steelhead (*Oncorhynchus* sp.) stocks have declined substantially from their historical numbers and now are at a fraction of their historical abundance. Several factors contribute to these declines, including overfishing, loss of freshwater and estuarine habitat, hydropower development, poor ocean conditions, and hatchery practices. These factors collectively led to the National Marine Fisheries Service's (NMFS) listing of 28 salmon and steelhead stocks in California, Idaho, Oregon, and Washington under the Federal Endangered Species Act (ESA).

The ESA, under section 4(c)(2), directs the Secretary of Commerce to review the listing classification of threatened and endangered species at least once every five years. A 5-year review is a periodic analysis of a species' status conducted to ensure that the listing classification of a species as threatened or endangered on the List of Endangered and Threatened Wildlife and Plants (List) (50 CFR 17.11 – 17.12; 50 CFR 223.102, 224.101) is accurate (USFWS and NMFS 2006; NMFS 2020a). After completing this review, the Secretary must determine if any species should: (1) be removed from the list; (2) have its status changed from endangered to threatened; or (3) have its status changed from threatened to endangered. If, in the 5-year review, a change in classification is recommended, the recommended change will be further considered in a separate rule-making process. The most recent 5-year review analysis for West Coast salmon and steelhead occurred in 2016. This document describes the results of the 2021 5-year review of ESA-listed lower Columbia River salmon and steelhead species: Lower Columbia River Chinook (LCR) salmon, Columbia River (CR) chum salmon, Lower Columbia River (LCR) coho salmon, and Lower Columbia River (LCR) steelhead.

A 5-year review is:

- A summary and analysis of available information on a given species
- The tracking of a species' progress toward recovery
- The recording of the deliberative process used to make a recommendation on whether or not to reclassify a species
- A recommendation on whether reclassification of the species is indicated

A 5-year review is not:

- A re-listing or justification of the original (or any subsequent) listing action
- A process that requires acceleration of ongoing or planned surveys, research, or modeling
- A petition process
- A rulemaking

1.1.1 Background on Listing Determinations

The ESA defines species to include subspecies and distinct population segments (DPS) of vertebrate species. A species may be listed as threatened or endangered. To identify taxonomically recognized species of Pacific salmon, we apply the "Policy on Applying the Definition of Species under the ESA to Pacific Salmon" (56 FR 58612). Under this policy, we identify population groups that are "evolutionarily significant units" (ESUs) within taxonomically recognized species. We consider a group of populations to be an ESU if it is substantially reproductively isolated from other populations within the taxonomically recognized species and represents an important component in the evolutionary legacy of the species. We consider an ESU as constituting a DPS and, therefore, a "species" under the ESA. Under the DPS policy, a DPS of steelhead must be discrete from other populations, and it must be significant to its taxon.

Artificial propagation programs (hatcheries) are common throughout the range of ESA-listed West Coast salmon and steelhead. Before 2005, our policy was to include in the listed ESU or DPS only those hatchery fish deemed "essential for conservation" of the species. We revised that approach in response to a court decision. On June 28, 2005, we announced a final policy[1] addressing the role of artificially propagated Pacific salmon and steelhead in listing determinations under the ESA (70 FR 37204) (Hatchery Listing Policy). This policy establishes criteria for including hatchery stocks in ESUs and DPSs. In addition, it (1) provides direction for considering hatchery fish in extinction risk assessments of ESUs and DPSs; (2) requires that hatchery fish determined to be part of an ESU or DPS be included in any listing of the ESU or DPS; (3) affirms our commitment to conserving natural salmon and steelhead populations and the ecosystems upon which they depend; and (4) affirms our commitment to fulfilling trust and treaty obligations with regard to the harvest of some Pacific salmon and steelhead populations, consistent with the conservation and recovery of listed salmon ESUs and steelhead DPSs.

To determine whether a hatchery program is part of an ESU or DPS, and therefore, must be included in the listing, we consider the origins of the hatchery stock, where the hatchery fish are released, and the extent to which the hatchery stock has diverged genetically from the donor stock. We include within the ESU or DPS (and therefore within the listing) hatchery fish that are no more than moderately diverged from the local population.

Because the Hatchery Listing Policy changed the way we considered hatchery fish in ESA listing determinations, we completed new status reviews and ESA listing determinations for West Coast salmon ESUs on June 28, 2005 (70 FR 37159), and for steelhead DPSs on January 5, 2006 (71 FR 834). On August 15, 2011, we published our 5-year reviews and listing determinations for 11 ESUs of Pacific salmon and 6 DPSs of steelhead from the Pacific Northwest (76 FR 50448). On May 26, 2016, we published our 5-year reviews and listing determinations for 17 ESUs of Pacific salmon, 10 DPSs of steelhead, and the southern DPS of eulachon (*Thaleichthys pacificus)* (81 FR 33468).

[1] Policy on the Consideration of Hatchery-Origin Fish in Endangered Species Act Listing Determinations for Pacific Salmon and Steelhead

1.2 Methodology Used to Complete the Review

On October 4, 2019, we announced the initiation of 5-year reviews for 17 ESUs of salmon and 11 DPSs of steelhead in Oregon, California, Idaho, and Washington (84 FR 53117). We requested that the public submit new information on these species that had become available since our 2015-2016 5-year reviews. In response to our request, we received information from federal and state agencies, Native American Tribes, conservation groups, fishing groups, and individuals. We considered this information, as well as information routinely collected by our agency, to complete these 5-year reviews.

To complete the reviews, we first asked scientists from our Northwest and Southwest Centers to collect and analyze new information about ESU and DPS viability. To evaluate viability, our scientists used the Viable Salmonid Population (VSP) concept described in the 2000 Technical Memorandum NOAA NMFS-NWFSC-42, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (hereafter referred to as (McElhany et al. 2000). The VSP concept evaluates four criteria -- abundance, productivity, spatial structure, and diversity – to assess species viability. By applying this concept, the Northwest Fisheries Science Center considered new information for a given ESU or DPS relative to the four salmon and steelhead population viability criteria. They also considered new information on ESU and DPS composition. At the end of this process, the science team prepared reports detailing the results of their analyses (Ford 2022).

To further inform the reviews, we also asked salmon management biologists from our West Coast Region familiar with hatchery programs to consider new information available since the previous listing determinations. Among other things, they considered whether any hatchery programs have ended, or new hatchery programs have started, any changes in the operation of existing programs, and scientific data relevant to the degree of divergence of hatchery fish from naturally spawning fish in the same area. Finally, we consulted salmon management biologists from the West Coast Region who are familiar with habitat conditions, hydropower operations, and harvest management. In a series of structured meetings, by geographic area, these biologists identified relevant information and provided insight on the degree to which circumstances had changed for each listed entity.

In preparing this report, we considered the best available scientific information, including the work of the Northwest Fisheries Science Center (Ford 2022); the report of the regional biologists regarding hatchery programs; recovery plans for the species in question; technical reports prepared in support of recovery plans for the species in question; the listing record (including designation of critical habitat and adoption of protective regulations); the recent biological opinions issued for Lower Columbia River salmon and steelhead; information submitted by the public and other government agencies; and the information and views provided by the geographically based management teams. The present report describes the agency's findings based on all of the information considered.

1.3 Background – Summary of Previous Reviews, Statutory and Regulatory Actions, and Recovery Planning

1.3.1 Federal Register Notice Announcing Initiation of this Review

84 FR 53117; October 4, 2019.

1.3.2 Listing History

Beginning in 1998, NMFS began listing salmonid species in the lower Columbia River under the ESA. Over the next several years, four species of salmonids in this area were listed as threatened (Table 1).

Table 1. Summary of the listing history under the Endangered Species Act for ESUs and DPS in the Lower Columbia River.

Salmonid Species	ESU/DPS Name	Original Listing	Revised Listing(s)
Chinook Salmon (*O. tshawytscha*)	Lower Columbia River Chinook Salmon	**FR Notice:** 64 FR 14308 **Date:** 3/24/1999 **Classification:** Threatened	**FR Notice:** 70 FR 37159 **Date:** 6/28/2005 **Re-classification:** Threatened
Chum Salmon (*O. keta*)	Columbia River Chum Salmon	**FR Notice:** 64 FR 14508 **Date:** 3/25/1999 **Classification:** Threatened	**FR Notice:** 70 FR 37159 **Date:** 6/28/2005 **Re-classification:** Threatened
Coho Salmon (*O. kisutch*)	Lower Columbia River Coho Salmon	**FR Notice:** 70 FR 37159 **Date:** 6/28/2005 **Classification:** Threatened	NA
Steelhead (*O. mykiss*)	Lower Columbia River Steelhead	**FR Notice:** 63 FR 13347 **Date:** 3/19/1998 **Classification:** Threatened	**FR Notice:** 71 FR 834 **Date:** 1/5/2006 **Re-classification:** Threatened

1.3.3 Associated Rulemakings

The ESA requires NMFS to designate critical habitat, to the maximum extent prudent and determinable, for species it lists under the ESA. Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time of listing, that contain physical or biological features essential to conservation, that may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time of listing that are essential for the conservation of the species. We designated critical habitat for LCR Chinook salmon, CR chum salmon, and LCR steelhead in 2005, and we designated critical habitat for LCR coho salmon in 2016 (Table 2).

Section 9 of the ESA prohibits the take of species listed as endangered. The ESA defines take to mean harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. For threatened species, the ESA does not automatically prohibit take, but instead authorizes the agency to adopt regulations it deems necessary and advisable for species conservation and to apply the take prohibitions of section 9(a)(1) through ESA section 4(d). In 2000, NMFS adopted 4(d) regulations for threatened salmonids that prohibit take except in specific circumstances. In 2005, we revised our 4(d) regulations for consistency between ESUs and DPSs, and to take into account our Hatchery Listing Policy (65 FR 42421; July 10, 2000).

Table 2. Summary of rulemaking for 4(d) protective regulations and critical habitat for ESUs and DPS in the Lower Columbia River.

Salmonid Species	ESU Name	4(d) Protective Regulations	Critical Habitat Designations
Chinook Salmon (*O. tshawytscha*)	Lower Columbia River Chinook Salmon	**FR notice:** 65 FR 42421 **Date:** 7/10/2000 **Revised:** 6/28/2005 (70 FR 37159)	**FR Notice:** 70 FR 52630 **Date:** 9/2/2005
Chum Salmon (*O. keta*)	Columbia River Chum Salmon	**FR notice:** 65 FR 42421 **Date:** 7/10/2000 **Revised:** 6/28/2005 (70 FR 37159)	**FR Notice:** 70 FR 52630 **Date:** 9/2/2005
Coho Salmon (*O. kisutch*)	Lower Columbia River Coho Salmon	**FR Notice:** 70 FR 37159 **Date:** 6/28/2005	**FR Notice:** 81 FR 9252 **Date:** 2/24/2016
Steelhead (*O. mykiss*)	Lower Columbia River Steelhead	**FR notice:** 65 FR 42421 **Date:** 7/10/2000 **Revised:** 6/28/2005 (70 FR 37159)	**FR notice:** 70 FR 52630 **Date:** 9/2/2005

1.3.4 Review History

Table 3 lists the numerous scientific assessments of the status of lower Columbia River salmon ESUs and steelhead DPS. These assessments include status reviews conducted by our Northwest

Fisheries Science Center and technical reports prepared to support recovery planning for these species.

Table 3. Summary of previous scientific assessments for the ESUs and DPS in the Lower Columbia River.

Salmonid Species	ESU Name	Document Citation
Chinook Salmon (*O. tshawytscha*)	Lower Columbia River Chinook Salmon	Ford 2022 NWFSC 2015 Ford et al. 2011 LCFRB 2010 ODFW 2010 McElhany et al. 2007 Myers et al. 2006 WLCTRT and ODFW 2006 Good et al. 2005 Maher et al. 2005 NMFS 2005 LCFRB 2004 WLCTRT 2004 WLCTRT 2003 NMFS 1999b NMFS 1998b NMFS 1998c
Chum Salmon (*O. keta*)	Columbia River Chum Salmon	Ford 2022 NWFSC 2015 Ford et al. 2011 LCFRB 2010 ODFW 2010 McElhany et al. 2007 Myers et al. 2006 WLCTRT and ODFW 2006 Good et al. 2005 Maher et al. 2005 NMFS 2005 LCFRB 2004 WLCTRT 2004 WLCTRT 2003 NMFS 1999a NMFS 1999b NMFS 1997c

Salmonid Species	ESU Name	Document Citation
Coho Salmon (*O. kisutch*)	Lower Columbia River Coho Salmon	Ford 2022 NWFSC 2015 Ford et al. 2011 LCFRB 2010 ODFW 2010 McElhany et al. 2007 Myers et al. 2006 WLCTRT and ODFW 2006 Good et al. 2005 Maher et al. 2005 NMFS 2005 LCFRB 2004 WLCTRT 2004 WLCTRT 2003 NMFS 1996b Weitkamp et al. 1995 Johnson et al. 1991
Steelhead (*O. mykiss*)	Lower Columbia River Steelhead	Ford 2022 NWFSC 2015 Ford et al. 2011 LCFRB 2010 ODFW 2010 McElhany et al. 2007 Myers et al. 2006 WLCTRT and ODFW 2006 Good et al. 2005 Maher et al. 2005 NMFS 2005 LCFRB 2004 WLCTRT 2004 WLCTRT 2003 NMFS 1998a NMFS 1997a NMFS 1997b NMFS 1996a

1.3.5 Species' Recovery Priority Number at Start of 5-Year Review Process

On April 30, 2019, NMFS issued new guidelines (84 FR 18243) for assigning listing and recovery priorities. Under these guidelines, we assign each species a recovery priority number, ranging from 1 (high) to 11 (low). This priority number reflects the species demographic risk (based on the listing status and species' condition in terms of its productivity, spatial distribution, diversity, abundance, and trends) and recovery potential (major threats understood, management actions exist under U.S. authority or influence to abate major threats, and certainty that actions will be effective). Additionally, if the listed species is in conflict with construction or other development projects or other forms of economic activity, then they are assigned a 'C' and are given a higher priority over those species that are not in conflict. Table 4 lists the recovery priority number for the subject species that was in effect at the time this 5-year review began (NMFS 2019a). In January 2022, NMFS issued a new report with updated recovery priority numbers. With the exception of LCR Coho Salmon, the numbers remained unchanged (NMFS

2022). For LCR Coho Salmon, the number was revised from 4C to 3C.

1.3.6 Recovery Plan or Outline

Table 4. Recovery Priority Number (NMFS 2019a) and Endangered Species Act Recovery Plans for the ESUs and DPS in the lower Columbia River.

Salmonid Species	ESU Name	Recovery Priority Number	Recovery Plans/Outline
Chinook Salmon (*O. tshawytscha*)	Lower Columbia River Chinook Salmon	**3C**	**Title:** ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead **Available at:** https://www.fisheries.noaa.gov/resource/document/recovery-plan-lower-columbia-river-coho-salmon-lower-columbia-river-chinook **Date:** July 12, 2013 **Type:** Final **FR Notice:** 78 FR 41911
Chum Salmon (*O. keta*)	Columbia River Chum Salmon	**3C**	**Title:** ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead **Available at:** **https://www.fisheries.noaa.gov/resource/document/recovery-plan-lower-columbia-river-coho-salmon-lower-columbia-river-chinook** **Date:** July 12, 2013 **Type:** Final **FR Notice:** 78 FR 41911

Salmonid Species	ESU Name	Recovery Priority Number	Recovery Plans/Outline
Coho Salmon (*O. kisutch*)	Lower Columbia River Coho Salmon	**4C**	**Title:** ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead **Available at:** https://www.fisheries.noaa.gov/resource/document/recovery-plan-lower-columbia-river-coho-salmon-lower-columbia-river-chinook **Date:** July 12, 2013 **Type:** Final **FR Notice:** 78 FR 41911
Steelhead (*O. mykiss*)	Lower Columbia River Steelhead	**3C**	**Title:** ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead **Available at:** https://www.fisheries.noaa.gov/resource/document/recovery-plan-lower-columbia-river-coho-salmon-lower-columbia-river-chinook **Date:** July 12, 2013 **Type:** Final **FR Notice:** 78 FR 41911

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2. Review Analysis

In this section, we review new information to determine whether species' delineations remain appropriate.

2.1 Delineation of Species under the Endangered Species Act

Is the species under review a vertebrate?

ESU Name	YES	NO
Lower Columbia River Chinook Salmon	X	
Columbia River Chum Salmon	X	
Lower Columbia River Coho Salmon	X	
Lower Columbia River Steelhead	X	

Is the species under review listed as an ESU/DPS?

ESU Name	YES	NO
Lower Columbia River Chinook Salmon	X	
Columbia River Chum Salmon	X	
Lower Columbia River Coho Salmon	X	
Lower Columbia River Steelhead	X	

Was the ESU/DPS listed prior to 1996?

ESU Name	YES	NO	Date Listed if Prior to 1996
Lower Columbia River Chinook Salmon		X	N/A
Columbia River Chum Salmon		X	N/A
Lower Columbia River Coho Salmon		X	N/A
Lower Columbia River Steelhead		X	N/A

Prior to this 5-year review, was the ESU/DPS classification reviewed to ensure it meets the 1996 DPS policy standards?

In 1991, NMFS issued a policy explaining how the agency would apply the definition of "species" in evaluating Pacific salmon stocks for listing consideration under the ESA (56 FR 58612). Under this policy, a group of Pacific salmon populations is considered a "species" under the ESA if it represents an "evolutionarily significant unit" (ESU) which meets the two criteria of being substantially reproductively isolated from other con-specific populations, and it represents an important component in the evolutionary legacy of the biological species. The 1996 joint NMFS-Fish and Wildlife Service (FWS) "distinct population segment" (DPS) policy (61 FR 4722) affirmed that a stock (or stocks) of Pacific salmon is considered a DPS if it represents an ESU of a biological species. Accordingly, in listing the Lower Columbia River steelhead DPS under the DPS policy in 1998, we used the joint DPS policy to delineate the DPS under the ESA.

2.1.1 Summary of Relevant New Information Regarding Delineation of the Lower Columbia River ESUs/DPS

ESU/DPS Delineation

This section provides a summary of information presented in Ford 2022: Biological viability assessment update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest.

We found no new information that would justify a change in the delineation of the LCR Chinook Salmon ESU, the LCR Coho Salmon ESU, or the CR Chum Salmon ESU (Ford 2022).

However, in the 2015 report NWFSC recommended a revision of the Lower Columbia River Steelhead DPS and Upper Willamette River Steelhead DPS composition. Specifically, the NWFSC recommended that the Clackamas River winter steelhead demographically independent population (DIP), originally included as part of the Lower Columbia River DPS, instead be included in the Upper Willamette River DPS (NWFSC 2015). Genetic research published since 2015 further supports the closer affinity of the Clackamas River winter-run steelhead DIP to Upper Willamette River steelhead DPS populations rather than Lower Columbia River steelhead DPS populations (Winans et al. 2018). The recommendation has not been carried forward. The NWFSC (2022) determined that the rationale for revising the placement of the Clackamas River winter steelhead DIP originally stated in the NWFSC 2015 report is still accurate and appropriate and does not need revision (Ford 2022).

Membership of Hatchery Programs

For West Coast salmon and steelhead, many of the ESU and DPS descriptions include fish originating from specific artificial propagation programs (e.g., hatcheries) that, along with their naturally produced counterparts, are included as part of the listed species. NMFS' Hatchery Listing Policy (70 FR 37204, June 28, 2005) guides our analysis of whether individual hatchery programs should be included as part of the listed species. The Hatchery Listing Policy states that hatchery programs will be considered part of an ESU/DPS if they exhibit a level of genetic divergence relative to the local natural population(s) that is not more than what occurs within the ESU/DPS.

In preparing this report, our hatchery management biologists reviewed the best available information regarding hatchery membership of this ESU. They considered changes in hatchery programs that occurred since the last 5-year review (e.g., some have been terminated while others are new) and made recommendations about the inclusion or exclusion of specific programs. They also noted any errors and omissions in the existing descriptions of hatchery program membership. NMFS intends to address any needed changes and corrections via separate rulemaking after the completion of the 5-year review process and before any official change in hatchery membership.

LCR Chinook Salmon

In the 2016 5-year review, the LCR Chinook salmon ESU was defined as including all naturally spawned Chinook salmon originating from the Columbia River and its tributaries downstream of a transitional point east of the Hood and White Salmon rivers, and any such fish originating from the Willamette River and its tributaries below Willamette Falls. Not included in this ESU are: (1) Spring-run Chinook salmon originating from the Clackamas River; (2) fall-run Chinook salmon originating from Upper Columbia River bright hatchery stocks, that spawn in the mainstem Columbia River below Bonneville Dam, and in other tributaries upstream from the Sandy River to the Hood and White Salmon Rivers; (3) spring-run Chinook salmon originating from the Round Butte Hatchery (Deschutes River, Oregon) and spawning in the Hood River; (4) spring-run Chinook salmon originating from the Carson National Fish Hatchery and spawning in the Wind River; and (5) naturally spawned Chinook salmon originating from the Rogue River Fall Chinook Program. The ESU does includes Chinook salmon from 15 artificial propagation programs (70 FR 37159, June 28, 2005).[2]

Since 2016, we added four hatchery programs to the LCR Chinook Salmon ESU (85 FR 81822, December 17, 2020): Deep River Net Pens-Washougal Program; Klaskanine Hatchery Program; Bonneville Hatchery Program; and the Cathlamet Channel Net Pens Program. We also changed the name of the Sandy River Hatchery Spring Chinook Salmon (ODFW stock #11) program to the Sandy River Hatchery Program to be consistent with other ODFW hatchery programs that have had the "stock #" removed from the listed hatchery program name (85 FR 81822, December 17, 2020).

The addition or removal of an artificial propagation program from an ESU does not necessarily affect the listing status of the ESU; however, it revises the ESU's composition to reflect the best available scientific information as considered under our Hatchery Listing Policy. Addition of an artificial propagation program to an ESU represents our determination that the artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37204, June 28, 2005). We relied on the Hatchery Listing Policy in our 2020 Final Rule on Revisions to Hatchery Programs as Part of Pacific Salmon and Steelhead Species Listed under the Endangered Species Act (85 FR 81822, December 17, 2020).

[2] Big Creek Tule Fall Chinook; Astoria High School Salmon-Trout Enhancement Program (STEP) Tule Chinook Program; Warrenton High School (STEP) Tule Chinook Program; Cowlitz Tule Chinook Program; North Fork Toutle Tule Chinook Program; Kalama Tule Chinook Program; Washougal River Tule Chinook Program; Spring Creek National Fish Hatchery (NFH) Tule Chinook Program; Cowlitz Spring Chinook Program in the Upper Cowlitz River and in the Cispus River; Friends of the Cowlitz Spring Chinook Program; Kalama River Spring Chinook Program; Lewis River Spring Chinook Program; Fish First Spring Chinook Program; and Sandy River Hatchery Spring Chinook salmon (ODFW stock #11).

The ongoing Hood River Spring Chinook Salmon Program is currently integrating returning natural-origin spring Chinook salmon into the broodstock. The program had been using only spring Chinook salmon returning to the Hood River for broodstock since the release year 2013 when the last release of out-of-basin Deschutes River spring Chinook salmon occurred (NMFS 2018a). Currently the Hood River spring Chinook salmon hatchery broodstock consists solely of spring Chinook salmon returning to the Hood River since the release year 2013 and the program is being managed to encourage local adaptation (i.e., incorporation of natural-origin fish into the broodstock). NMFS will continue to monitor the status of the natural-origin population to determine if the Hood River spring Chinook salmon artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37204, June 28, 2005).

CR Chum Salmon

In the 2016 5-year review, the CR Chum salmon ESU was defined as including naturally spawned chum salmon populations originating from the Columbia River and its tributaries in Washington and Oregon. The ESU also includes chum salmon from two artificial propagation programs: the Grays River Program and the Washougal River Hatchery/Duncan Creek Program (70 FR 37159, June 28, 2005).

Since 2016, we added the Big Creek Hatchery Program because the source for these fish is local natural-origin fish from the Grays River, which is included in the ESU (85 FR 81822, December 17, 2020).

The addition or removal of an artificial propagation program from an ESU does not necessarily affect the listing status of the ESU; however, it revises the ESU's composition to reflect the best available scientific information as considered under our Hatchery Listing Policy. Addition of an artificial propagation program to an ESU represents our determination that the artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37204, June 28, 2005). We relied on the Hatchery Listing Policy in our 2020 Final Rule on Revisions to Hatchery Programs as Part of Pacific Salmon and Steelhead Species Listed under the Endangered Species Act (85 FR 81822, December 17, 2020).

LCR Coho Salmon

In the 2016 5-year review, the LCR Coho Salmon ESU was defined as including naturally spawned coho salmon originating from the Columbia River and its tributaries downstream from the Big White Salmon and Hood rivers (inclusive) and any such fish originating from the Willamette River and its tributaries below Willamette Falls. The ESU also includes coho salmon from 21 artificial propagation programs: the Grays River Program; Peterson Coho Project; Big Creek Hatchery Program (Oregon Department of Fish and Wildlife (ODFW) Stock #13); Astoria High School Salmon-Trout Enhancement Program (STEP) Coho Program; Warrenton High School STEP Coho Program; Cowlitz Type-N Coho Program in the Upper and Lower Cowlitz Rivers; Cowlitz Game and Anglers Coho Program; Friends of the Cowlitz Coho Program; North Fork Toutle River Hatchery Program; Kalama River Type-N Coho Program; Kalama River

Type-S Coho Program; Lewis River Type-N Coho Program; Lewis River Type-S Coho Program; Fish First Wild Coho Program; Fish First Type-N Coho Program; Syverson Project Type-N Coho Program; Washougal River Type-N Coho Program; Eagle Creek National Fish Hatchery Program; Sandy Hatchery Program (ODFW Stock #11); and the Bonneville/Cascade/Oxbow Complex (ODFW Stock #14) Hatchery Program (70 FR 37159, June 28, 2005).

Since 2016, five artificial propagation programs changed. We added the Clatsop County Fisheries Net Pen Program because the broodstock origin is Tanner Creek, which is included in the ESU. We also added the Clatsop County Fisheries/Klaskanine Hatchery Program because the source for these fish is the Big Creek Hatchery Program, which is included in the ESU. We removed the Kalama River Type-S Coho program because the program was terminated. We also changed the names of four hatchery programs that are currently in the ESU: we removed the ODFW stock numbers from the names of the Big Creek Hatchery Program, Sandy Hatchery Program, and Bonneville/Cascade/Oxbow Complex Hatchery Program; and changed the name of the North Fork Toutle River Hatchery program to the North Fork Toutle River Type-S Hatchery program (85 FR 81822, December 17, 2020).

We currently have an ongoing program, the Beaver Creek Hatchery Type-N Coho Program that has two components: an integrated/conservation component and a segregated/harvest component. The integrated component utilizes the Elochoman River's natural-origin later-returning coho salmon for broodstock. The segregated program uses returning hatchery-origin adults from the integrated program for broodstock. The segregated program's goal is to provide harvest opportunities while conserving the natural population and reducing the hatchery program's effects on the ESU. The segregated component releases 700,000 yearlings from the Deep River Net Pens. The integrated component directly releases 225,000 yearlings from the Beaver Creek Hatchery, located on Beaver Creek, a tributary to the Elochoman River (NMFS 2017a).

We also currently have a second ongoing program -- the Deep River Net Pens Coho Program. This program releases coho salmon acclimated in net pens in the Deep River near the mouth of the Grays River to support off-Columbia River mainstem commercial fisheries as part of the SAFE (Select Area Fisheries Evaluation) project (NMFS 2017a). In the past, the program released a mix of Grays River (within the major population group (MPG)) and Lewis River (outside MPG) coho salmon juveniles from the net pens. Under the new Mitchell Act Biological Opinion (NMFS 2017a), the program is transitioning to using only juveniles from the Beaver Creek program described above. The final program is expected to reduce impacts by eliminating the use of juveniles from outside the MPG as well as by reducing the total number released (NMFS 2017a). This program is similar to the Clatsop County Fisheries Net Pen program that is already included in the ESU (85 FR 81822, December 17, 2020).

Finally, we terminated the Fish First Wild Coho Program, with the last release in 2017.

The addition or removal of an artificial propagation program from an ESU does not necessarily affect the listing status of the ESU; however, it revises the ESU's composition to reflect the best available scientific information as considered under our Hatchery Listing Policy. Addition of an artificial propagation program to an ESU represents our determination that the artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37204, June 28, 2005). We relied on the Hatchery Listing Policy in our 2020 Final Rule on Revisions to Hatchery Programs as Part of Pacific Salmon and Steelhead Species Listed under the Endangered Species Act (85 FR 81822, December 17, 2020).

LCR Steelhead DPS

In the 2016 5-year review, the LCR Steelhead DPS was defined as including naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive); and excludes such fish originating from the upper Willamette River basin above Willamette Falls. This DPS does include steelhead from six artificial propagation programs: Cowlitz Trout Hatchery Late Winter-run Program (Lower Cowlitz); Kalama River Wild Winter-run and Summer-run Programs; Clackamas Hatchery Late Winter-run Program Oregon Department of Fish and Wildlife (ODFW) Stock #122); Sandy Hatchery Late Winter-run Program (ODFW Stock #11); Hood River Winter-run Program (ODFW Stock #50); and the Lewis River Wild Late-run Winter Steelhead Program (71 FR 834, January 5, 2006).

Since 2016, we (1) added the recently initiated Upper Cowlitz Wild Program because the source for these fish is local, natural-origin fish from the Upper Cowlitz River, which is included in the DPS; (2) added the recently initiated Tilton River Wild Program because the source for these fish is local, natural-origin fish from the Tilton River; and (3) removed ODFW stock numbers from the names of the Clackamas Hatchery Late Winter-run Program, Sandy Hatchery Late Winter-run Program, and Hood River Winter-run Program (85 FR 81822, December 17, 2020).

The addition or removal of an artificial propagation program from a DPS does not necessarily affect the listing status of the DPS; however, it revises the DPS's composition to reflect the best available scientific information as considered under our Hatchery Listing Policy. Addition of an artificial propagation program to a DPS represents our determination that the artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the DPS (70 FR 37204, June 28, 2005). We relied on the Hatchery Listing Policy in our 2020 Final Rule on Revisions to Hatchery Programs as Part of Pacific Salmon and Steelhead Species Listed under the Endangered Species Act (85 FR 81822, December 17, 2020).

The Eagle Creek NFH Late Winter Steelhead Program previously reared and released winter steelhead at the Eagle Creek NFH that were a mix of local and out-of-DPS Big Creek Hatchery early winter steelhead. The last release of locally adapted Eagle Creek winter stock took place in 2015; these fish are no longer spawned and are functionally extinct (Peterschmidt, USFWS, personal communication December 1, 2021). Fish released as part of the Eagle Creek NFH program now come from the Clackamas Hatchery Late Winter Steelhead Program that is currently included in the LCR Steelhead DPS.

2.2 Recovery Criteria

The ESA requires recovery plans be developed for each listed species unless the Secretary finds a recovery plan would not promote the conservation of the species. Recovery plans must contain, to the maximum extent practicable, objective measurable criteria for delisting the species, site-specific management actions necessary to recover the species, and time and cost estimates for implementing the recovery plan.

Evaluating a species for potential changes in ESA listing requires an explicit analysis of population or demographic parameters (the biological recovery criteria) and also of threats under the five ESA listing factors in ESA section 4(a)(1) (listing factor [threats] criteria). Together these make up the objective, measurable criteria required under section 4(f)(1)(B).

Technical Recovery Teams (TRTs), appointed by NMFS, define criteria to assess each listed Pacific salmonid species' biological viability. NMFS adopted the TRT's viability criteria as the biological criteria for Pacific salmonid recovery plans, based on the best available scientific information and other considerations as appropriate. NMFS also developed criteria to assess progress toward alleviating the relevant threats to Pacific salmonid species (listing factor [threats] criteria). For the ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead (hereafter referred to as the 2013 Recovery Plan) (NMFS 2013a), NMFS adopted the viability criteria metrics defined by the Willamette-Lower Columbia Technical Recovery Team (WLCTRT) (WLCTRT and ODFW 2006) as the biological recovery criteria for the ESA-listed Lower Columbia River salmon and steelhead species.

Biological review of the species continues as the recovery plan is implemented and additional information becomes available. This information, along with new scientific analyses, can increase certainty about whether the threats have been abated, whether improvements in population biological viability have occurred for the salmon and steelhead, and whether linkages between threats and changes in biological viability are understood. NMFS assesses these biological recovery criteria and the delisting criteria through the adaptive management program for the plan during the ESA 5-year review (USFWS and NMFS 2006; NMFS 2020a).

2.2.1 Approved Recovery Plan with Objective, Measurable Criteria

Do the species have a final, approved recovery plan containing objective, measurable criteria?

ESU/DPS Name	YES	NO
Lower Columbia River Chinook Salmon	X	
Columbia River Chum Salmon	X	
Lower Columbia River Coho Salmon	X	
Lower Columbia River Steelhead	X	

2.2.2 Adequacy of Recovery Criteria

Based on new information considered during this review, are the recovery criteria still appropriate?

ESU/DPS Name	YES	NO
Lower Columbia River Chinook Salmon	X	
Columbia River Chum Salmon	X	
Lower Columbia River Coho Salmon	X	
Lower Columbia River Steelhead	X	

Are all of the listing factors that are relevant to the species addressed in the recovery criteria?

ESU/DPS Name	YES	NO
Lower Columbia River Chinook Salmon	X	
Columbia River Chum Salmon	X	
Lower Columbia River Coho Salmon	X	
Lower Columbia River Steelhead	X	

2.2.3 List the Biological Recovery Criteria as They Appear in the Recovery Plan

Salmon ESUs and steelhead DPSs typically exhibit a metapopulation structure (Schtickzelle and Quinn 2007; McElhany et al. 2000). Rather than interbreeding as one large aggregation, ESUs and DPSs function as a group of demographically independent populations separated by areas of unsuitable spawning habitat. For conservation and management purposes, it is important to identify the independent populations that make up an ESU or DPS.

McElhany et al. (2000) defined an independent population as: "…a group of fish of the same species that spawns in a particular lake or stream (or portion thereof) at a particular season and which, to a substantial degree, does not interbreed with fish from any other group spawning in a different place or in the same place at a different season." For our purposes, not interbreeding to a "substantial degree" means that two groups are considered to be independent populations if they are isolated to such an extent that exchanges of individuals among the populations do not substantially affect the population dynamics or extinction risk of the independent populations over a 100-year time frame. Independent populations exhibit different population attributes that influence their abundance, productivity, spatial structure, and diversity. Independent populations are the units that are combined to form alternative recovery scenarios for multiple similar population groupings and ESU viability.

For recovery planning and development of recovery criteria, the WLCTRT identified independent populations within each of the four ESA-listed Lower Columbia River species and grouped them into genetically similar MPGs or strata (WLCTRT 2004; Myers et al. 2006). Recovery criteria and strategies outlined in the 2013 River Recovery Plan are targeted on achieving, at a minimum, the WLCTRT and ODFW (2006) biological viability criteria for each MPG in the ESUs/DPS.

All the TRTs used the same biological principles for developing their ESU/DPS and population viability criteria. These principles are described below and in more depth in the NMFS 2000 Technical Memorandum NOAA NMFS-NWFSC-42, *Viable Salmonid Populations and the Recovery of Evolutionarily Significant Units* (McElhany et al. 2000). The VSP concept (McElhaney et al. 2000) is based on the biological parameters of abundance, productivity, spatial structure, and diversity for an independent salmonid population to have a negligible risk of extinction over a 100-year time frame. While the ESU/DPS is the listed entity under the ESA, the ESU/DPS-level viability criteria are based on the collective viability of the individual populations that make up the ESU/DPS—their characteristics and their distribution throughout the ESU/DPS geographic range.

The VSP concept identifies the attributes, provides guidance for determining the conservation status of populations and larger-scale groupings of Pacific salmonids, and describes a general framework for how many and which populations within an ESU/DPS should be at a particular status for the ESU/DPS to have an acceptably low risk of extinction. The NMFS-appointed WLCTRT (2006) developed combined VSP criteria metrics that describe the probability of population extinction risk in 100 years in terms of population persistence probabilities (Table 5).

Table 5. Population persistence probabilities associated with persistence categories (WLCTRT 2003; WLCTRT and ODFW 2006).

Population Persistence Category	Probability of Population Persistence in 100 Years	Description
0	0-40%	Either extinct or very high risk of extinction.
1	40-75%	Relatively high risk of extinction in 100 years.
2	75-95%	Moderate risk of extinction in 100 years.
3	95-99%	Low ("negligible") risk of extinction in 100 years (viable salmonid population).
4	>99%	Very low risk of extinction in 100 years.

The biological recovery criteria in the 2013 Recovery Plan (NMFS 2013a) are based on the WLCTRT work that partitioned the populations of each listed salmonid species into different MPGs, or strata, and developed biological criteria and methodologies at three different levels: ESU/DPS, MPG (or stratum), and population (WLCTRT 2003; WLCTRT 2004; WLCTRT and ODFW 2006). The following are the WLCTRT's key points in defining a viable ESU/DPS:

- Every MPG or stratum that historically existed should have a high probability of persistence.
- Within each MPG or stratum, there should be at least two populations that have at least a 95 percent probability of persisting over a 100-year time frame.
- Within each MPG or stratum, the average viability of the populations should be 2.25 or higher, using the WLCTRT's scoring system. Functionally, this is equivalent to about half of the populations in the stratum being viable; a viable population is one whose persistence probability is high or very high.
- Populations targeted for viability should include those within the ESU/DPS that historically were the most productive ("core" populations) and that best represent the historical genetic diversity of the ESU/DPS ("genetic legacy" populations). In addition, viable populations should be geographically dispersed in a way that protects against the effects of catastrophic events.
- Viable populations should meet specific criteria for abundance, productivity, spatial structure, and diversity.

There are various ways to refer to extinction risk: viability, persistence probability, extinction risk, or—at the population level—population status. The 2013 recovery plan frequently uses the terms "persistence probability" and "population status." Only populations with a persistence probability of 95 percent or higher over a 100-year time frame are considered viable. These populations have a population status of high or very high (NMFS 2013a).

LCR Chinook Salmon ESU

The Lower Columbia River Chinook Salmon ESU includes all naturally spawned Chinook salmon originating from the Columbia River and its tributaries downstream of a transitional point east of the Hood and White Salmon Rivers, and any such fish originating from the Willamette River and its tributaries below Willamette Falls. Not included in this ESU are: (1) Spring-run Chinook salmon originating from the Clackamas River; (2) fall-run Chinook salmon originating from Upper Columbia River bright hatchery stocks, that spawn in the mainstem Columbia River below Bonneville Dam, and in other tributaries upstream from the Sandy River to the Hood and White Salmon Rivers; (3) spring-run Chinook salmon originating from the Round Butte Hatchery (Deschutes River, Oregon) and spawning in the Hood River; (4) spring-run Chinook salmon originating from the Carson National Fish Hatchery and spawning in the Wind River; and (5) naturally spawned Chinook salmon originating from the Rogue River Fall Chinook Program. This ESU includes Chinook salmon from 19 artificial propagation programs[3] (70 FR 37159, June 28, 2005; 85 FR 81822, December 17, 2020).

The ESU spans three distinct ecological regions: Coastal, Cascade, and Gorge (Figure 1). Myers et al. (2006) identified distinct life-histories (run and spawn timing) within ecological regions in this ESU as MPGs. In total, 32 historical demographically-independent populations were identified in the LCR Chinook Salmon ESU: 9 spring-run populations, 21 fall-run populations, and 2 late-fall run populations. The populations were organized into 6 MPGs based on run timing and ecological region.

[3] Big Creek Tule Fall Chinook; Astoria High School Salmon-Trout Enhancement Program (STEP) Tule Chinook Program; Warrenton High School (STEP) Tule Chinook Program; Cowlitz Tule Chinook Program; North Fork Toutle Tule Chinook Program; Kalama Tule Chinook Program; Washougal River Tule Chinook Program; Spring Creek National Fish Hatchery (NFH) Tule Chinook Program; Cowlitz Spring Chinook Program in the Upper Cowlitz River and in the Cispus River; Friends of the Cowlitz Spring Chinook Program; Kalama River Spring Chinook Program; Lewis River Spring Chinook Program; Fish First Spring Chinook Program; Sandy River Hatchery Program; Deep River Net Pens-Washougal Program; Klaskanine Hatchery Program; Bonneville Hatchery Program; and the Cathlamet Channel Net Pens Program.

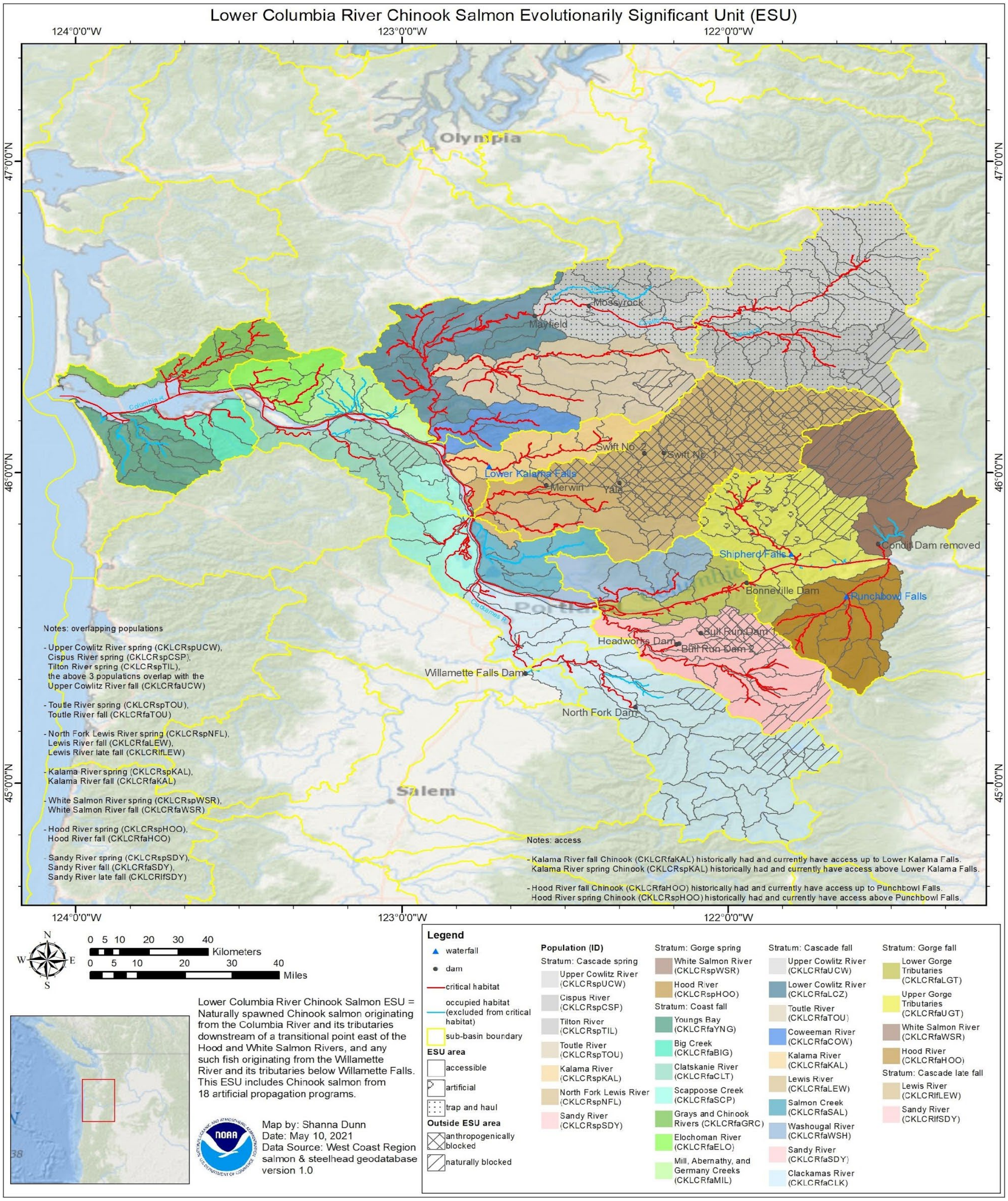

Figure 1. LCR Chinook Salmon ESU population structure[4].

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4 The map above generally shows the accessible and historically accessible areas for the Lower Columbia River Chinook salmon ESU. The area displayed is consistent with the regulatory description of the composition of the Lower Columbia River Chinook salmon found at 50 CFR17.11, 223.102, and 224.102. Actions outside the boundaries shown can affect this ESU. Therefore, these boundaries do not delimit the entire area that could warrant consideration in recovery planning or determining if an action may affect this ESU for the purposes of the ESA.

CR Chum Salmon ESU

The CR Chum Salmon ESU includes naturally spawned chum salmon originating from the Columbia River and its tributaries in Washington and Oregon. This ESU also includes chum salmon from the following artificial propagation programs: the Grays River Program; Washougal River Hatchery/Duncan Creek Program; and the Big Creek Hatchery Program (70 FR 37159, June 28, 2005; 85 FR 81822, December 17, 2020).

Myers et al. (2006) divided the CR Chum Salmon ESU into three major population groups (Coastal, Cascade, and Gorge) (Figure 2) with 17 demographically independent populations. There are seven chum salmon populations in the Coast MPG (Young Bay, Grays/Chinook, Big Creek, Elochoman/Skamakowa, Clatskanie, Mill/Abernathy/Germany, and Scappoose), eight populations in the Cascade MPG (Cowlitz-fall, Cowlitz-summer, Kalama, Lewis, Salmon Creek, Clackamas, Sandy, and Washougal), and two populations in the Gorge MPG (Lower Gorge and Upper Gorge) (NMFS 2013a).

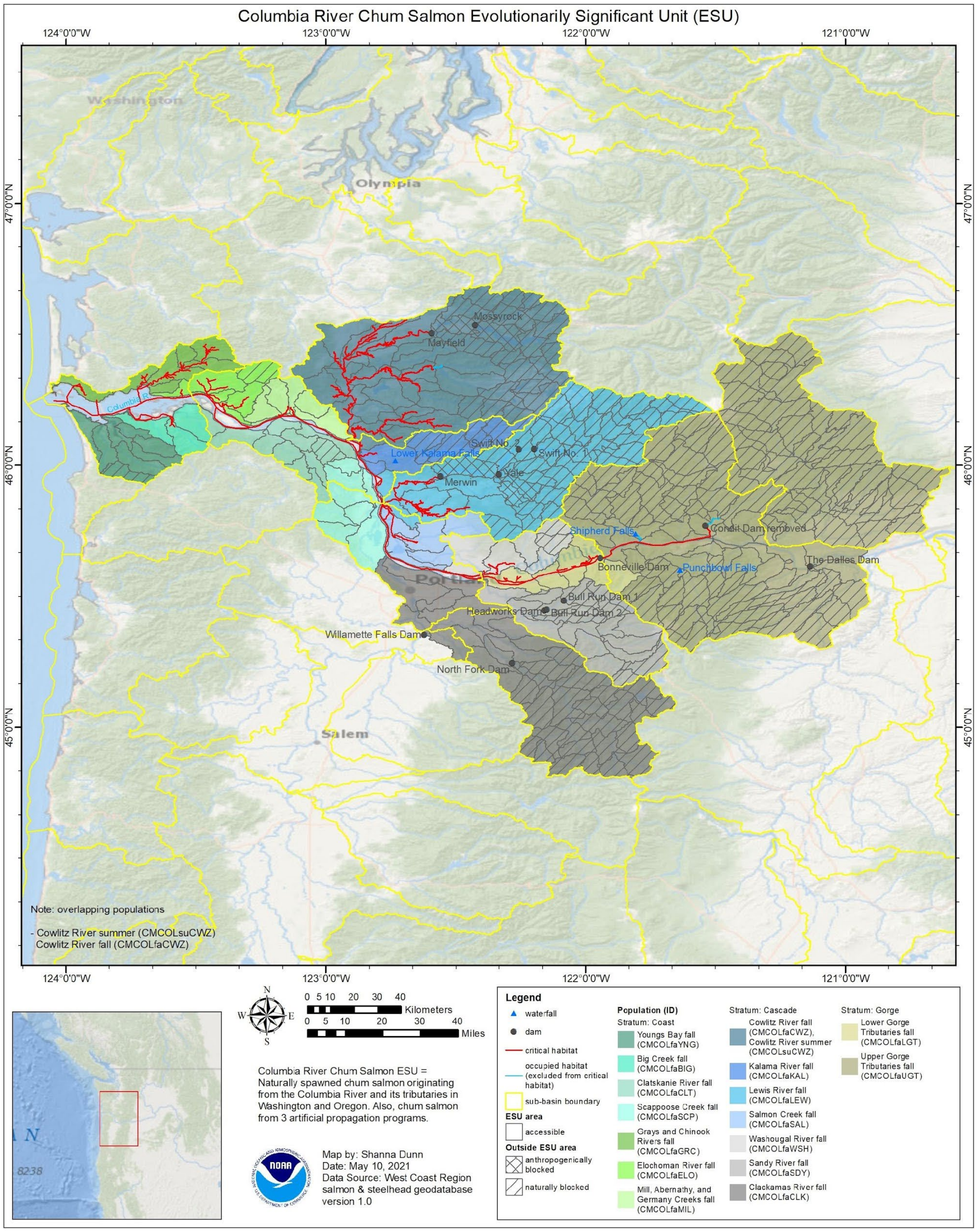

Figure 2. CR Chum Salmon ESU population structure[5].

[5] The map above generally shows the accessible and historically accessible areas for the Columbia River Chum salmon ESU. The area displayed is consistent with the regulatory description of the composition of the Columbia River Chum salmon found at 50 CFR17.11, 223.102, and 224.102. Actions outside the boundaries shown can affect this ESU. Therefore, these boundaries do not delimit the entire area that could warrant consideration in recovery planning or determining if an action may affect this ESU for the purposes of the ESA.

LCR Coho Salmon ESU

The Lower Columbia River Coho Salmon ESU includes all naturally spawned coho salmon originating from the Columbia River and its tributaries downstream from the Big White Salmon and Hood Rivers (inclusive) and any such fish originating from the Willamette River and its tributaries below Willamette Falls. This ESU also includes coho salmon from 21 artificial propagation programs[6] (70 FR 37159, June 28, 2005; 85 FR 81822, December 17, 2020).

Myers et al. (2006) identified three MPGs (Coastal, Cascade, and Gorge), containing a total of 24 demographically independent populations in the Lower Columbia River Coho Salmon ESU (Figure 3). There are seven populations in the Coast MPG (Youngs Bay, Grays/Chinook, Big Creek, Elochoman/Skamokawa, Clatskanie, Mill/Abernathy/Germany, and Scappoose), 14 coho salmon populations in the Cascade MPG (Lower Cowlitz, Upper Cowlitz, Cispus, Tilton, South Fork (SF) Toutle, North Fork (NF) Toutle, Coweeman, Kalama, NF Lewis, East Fork (EF) Lewis, Salmon Creek, Clackamas, Sandy, and Washougal), and three populations in the Gorge MPG (Lower Gorge, Upper Gorge/White Salmon, and Upper Gorge/Hood).

[6] The Grays River Program; Peterson Coho Project; Big Creek Hatchery Program; Astoria High School Salmon-Trout Enhancement Program (STEP) Coho Program; Warrenton High School STEP Coho Program; Cowlitz Type-N Coho Program in the Upper and Lower Cowlitz Rivers; Cowlitz Game and Anglers Coho Program; Friends of the Cowlitz Coho Program; North Fork Toutle River Type-S Hatchery Program; Kalama River Type-N Coho Program; Lewis River Type-N Coho Program; Lewis River Type-S Coho Program; Fish First Wild Coho Program; Fish First Type-N Coho Program; Syverson Project Type-N Coho Program; Washougal River Type-N Coho Program; Eagle Creek National Fish Hatchery Program; Sandy Hatchery Program; Bonneville/Cascade/Oxbow Complex Hatchery Program; Clatsop County Fisheries Net Pen Program; and the Clatsop County Fisheries/Klaskanine Hatchery Program.

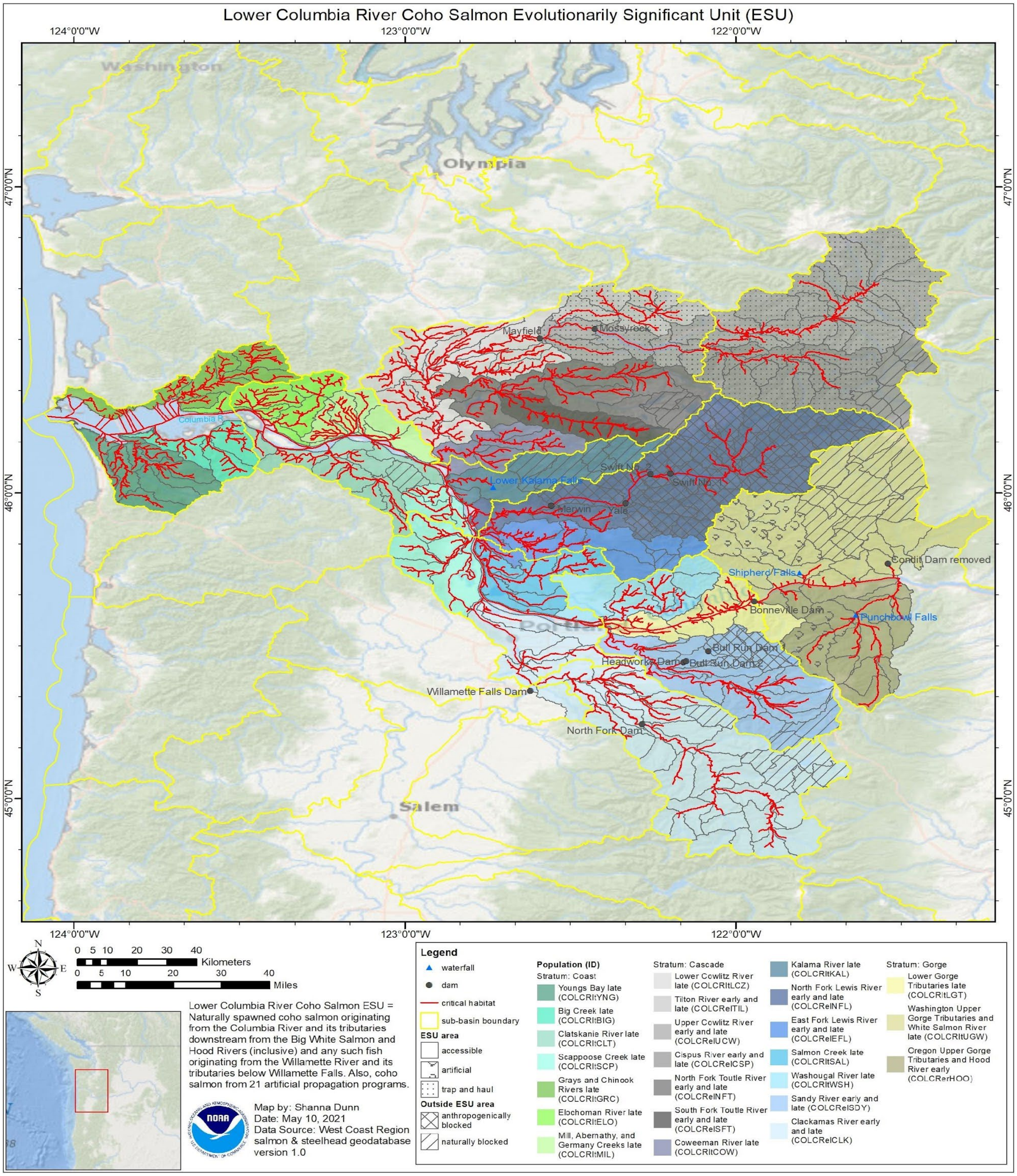

Figure 3. LCR Coho Salmon ESU population structure[7].

[7] The map above generally shows the accessible and historically accessible areas for the Lower Columbia River Coho salmon ESU. The area displayed is consistent with the regulatory description of the composition of the Lower Columbia River Coho salmon found at 50 CFR17.11, 223.102, and 224.102. Actions outside the boundaries shown can affect this ESU. Therefore, these boundaries do not delimit the entire area that could warrant consideration in recovery planning or determining if an action may affect this ESU for the purposes of the ESA.

LCR Steelhead DPS

The Lower Columbia River steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from rivers between the Cowlitz and Wind Rivers (inclusive) and the Willamette and Hood Rivers (inclusive); excludes such fish originating from the upper Willamette River basin above Willamette Falls. This DPS includes steelhead from the following artificial propagation programs: the Cowlitz Trout Hatchery Late Winter-run Program (Lower Cowlitz); Kalama River Wild Winter-run and Summer-run Programs; Clackamas Hatchery Late Winter-run Program; Sandy Hatchery Late Winter-run Program; Hood River Winter-run Program; Lewis River Wild Late-run Winter Steelhead Program; Upper Cowlitz Wild Program; and the Tilton River Wild Program (71 FR 834, January 5, 2006; 85 FR 81822, December 17, 2020).

Myers et al. (2006) identified two MPGs (Cascade and Gorge) (Figure 4) containing 23 demographically independent populations, including 6 summer-run steelhead populations and 17 winter-run populations. There are 14 steelhead populations in the Winter-run Cascade MPG (Lower Cowlitz, Upper Cowlitz, Cispus, Tilton, SF Toutle, NF Toutle, Coweeman, Kalama, NF Lewis, EF Lewis, Salmon Creek, Clackamas, Sandy, and Washougal), four populations in the Summer-run Cascade MPG (Kalama, NF Lewis, EF Lewis, and Washougal), three populations in the Winter-run Gorge MPG (Lower Gorge, Upper Gorge, and Hood), and two populations in the Summer-run Gorge MPG (Wind and Hood).

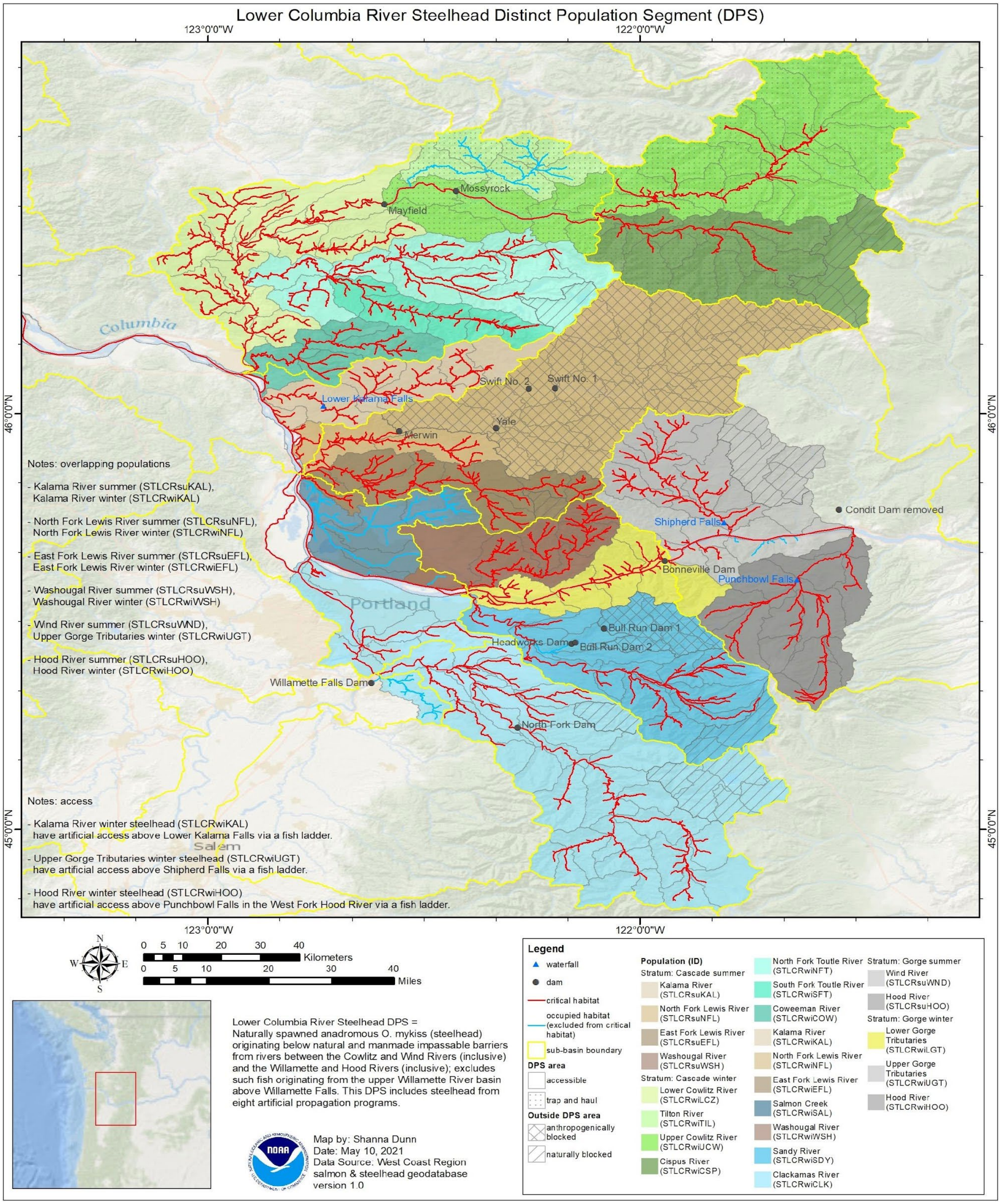

Figure 4. LCR Steelhead DPS population structure[8].

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[8] The map above generally shows the accessible and historically accessible areas for the Lower Columbia River Steelhead DPS. The area displayed is consistent with the regulatory description of the composition of the Lower Columbia River Steelhead DPS found at 50 CFR17.11, 223.102, and 224.102. Actions outside the boundaries shown can affect this DPS. Therefore, these boundaries do not delimit the entire area that could warrant consideration in recovery planning or determining if an action may affect this DPS for the purposes of the ESA.

2.3 Updated Information and Current Species' Status

In addition to recommending biological recovery criteria, the WLCTRT also assessed the current status of each population of LCR Chinook salmon, CR Chum salmon, LCR Coho salmon, and LCR Steelhead. Each population was rated against the biological criteria identified in previous assessments.

2.3.1 Analysis of VSP Criteria (including discussion of whether the VSP Criteria have been met)

Information provided in this section is summarized from Ford 2022—Biological viability assessment update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest.

Updated Biological Risk Summaries

LCR Chinook Salmon ESU

Overall, there has been modest change since the last review of the biological status of Chinook salmon populations in the Lower Columbia River ESU (NWFSC 2015), although some populations did exhibit marked improvements. Increases in abundance were noted in about half of the fall-run populations and 75% of the spring-run population for which data were available. Decreases in hatchery contribution were also noted for several populations. Relative to baseline VSP levels identified in the Recovery Plan (NMFS 2013a) there has been an overall improvement in the status of a number of fall-run populations, although most are still far from the recovery plan goals.

The biological status relative to the recovery goals show that of the 32 DIPs in this ESU, 7 of 32 populations are at or near the recovery viability goals set in the recovery plan (NMFS 2013a). The 7 DIPs included: 1 spring-run, 5 fall-run, and 1 late-fall-run DIP. Furthermore, 6 of the 7 DIPs were located in the Cascade Strata, with most of the populations in the Coastal and Gorge Strata doing rather poorly. Most of the remaining populations still require substantial improvements in abundance to reach their viability goals. The estimated proportion of hatchery-origin spawners was well in excess of the limits set in the recovery plan for many of the primary populations (NMFS 2013a). Of greater concern was the large number of DIPs (10) that either had no abundance information (presumed near zero) or exist at very low abundances. All of the Coastal and Gorge MPG fall-run populations (except the Lower Gorge DIP) likely fell within the high to very-high risk categories. Similarly, with the exception of the Sandy River spring-run DIP, all of the spring-run DIPs in the Cascade and Gorge MPGs are at high to very high risk categories, with a number of populations at or near zero, while others may only persist through hatchery supplementation. The Cascade fall-run MPG contains a number of populations above or near their recovery goals, while the Cascade late-fall MPG may be near viability although, there is some uncertainty in the abundance estimates for the Sandy-River late-fall DIP.

Improved fall-run status reflects both changes in biological status and improved monitoring. Spring-run Chinook populations in this ESU are generally unchanged; most of the populations are at a high or very high risk due to low abundances and the high proportion of hatchery-origin fish spawning naturally. In contrast, the spring-run Chinook salmon DIP in the Sandy River has a 5-year average of 3,359, nearly double the previous five-year average. This appears to be due, in part, to the removal of Marmot Dam (eliminating migration delays and passage injuries) and the diversion dam on the Little Sandy River (restoring access and flow to historical habitat). Elsewhere in the ESU, many of the spring-run populations rely upon passage programs at high head dams and downstream juvenile collection efficiencies are still too low to maintain self-sustaining natural runs. Limited numbers of naturally-produced spring run fish return to the Cowlitz and Cispus rivers (no spring-run fish are transported into the Tilton River Basin), and the status of spring-run Chinook salmon in the Toutle River Basin remains unclear. The removal of Condit Dam on the White Salmon River has provided an opportunity for the reestablishment of naturally-spawning fall and spring-run populations with volitional access to historical spawning grounds. The status of spring-run Chinook salmon in the Hood River is unclear; with the removal of Powerdale Dam, there is minimal monitoring in the basin and the abundance and genetic composition of returning spring-run Chinook salmon is unknown. It remains to be determined if any native spring-run Chinook salmon remain, or if they have been supplanted by Deschutes River (Middle Columbia River Spring Run Chinook Salmon ESU).

Many of the populations in this ESU remain at high risk, with low natural-origin abundance levels. Hatchery contributions remain high for a number of populations, and it is likely that many returning unmarked adults are the progeny of hatchery-origin parents, especially where large hatchery programs operate. While overall hatchery production has been reduced slightly, hatchery-produced fish still represent a majority of fish returning to the ESU. The continued release of out-of-ESU stocks, including Upriver Bright fall run, Rogue River (SAB) fall run, Upper Willamette River spring run, Carson Hatchery spring run, and Deschutes River spring run, remains a concern. Harvest rates are a potential concern, especially for low abundance tule fall-run populations. There have been a number of notable efforts to restore migratory access to areas upstream of dams, until efforts to improve juvenile passage systems bear fruition, it is unlikely that there will be significant improvements in the status of many spring-run populations. Alternatively, dam removals (Condit Dam, Marmot Dam, and Powerdale Dam) not only improve/provide access but allow the restoration of hydrological processes that may improve downstream habitat conditions. Continued land development and habitat degradation in combination with the potential effects of climate change may present a continuing strong negative influence into the foreseeable future. Finally, although many of the populations in this ESU are at high risk, it is important to note the poor ocean and freshwater conditions existed during the 2015-2019 period and despite these conditions the status of a number of populations improved, some remarkably so (Grays River, Lower Cowlitz River, and Kalama River fall runs). Overall, we conclude that the viability of the Lower Columbia River Chinook Salmon ESU has increased somewhat since the last 5-year review, although the ESU remains at moderate risk of extinction (Ford 2022).

CR Chum Salmon ESU

It is notable that during this most recent review period, three populations (Grays River, Washougal, and Lower Gorge DIPs) improved markedly in abundance. Improvements in productivity were observed in almost every year during the 2015-2019 interval. This is somewhat surprising, given that the majority of chum salmon emigrate to the ocean as subyearlings after only a few weeks, and one would have expected the poor ocean conditions to have had a strong negative influence on the survival of juveniles (as with many of the other ESUs in this region). In contrast to the three DIPs, the remaining populations in this ESU have not exhibited any detectable improvement in status. Abundances for these populations are assumed to be at or near zero and straying from nearby healthy populations does not seem sufficient to reestablish self-sustaining populations. It may be that the chum salmon life history strategy of emigrating post emergence *en masse* (possibly as a predator swamping mechanism) requires a critical minimum number of spawners to be effective.

Of the risk factors considered, freshwater habitat conditions may be negatively influencing spawning and early rearing success in some basins and contributing to the overall low productivity of the ESU. Recent studies also suggest that a freshwater parasite, *Ceratonova shasta*, may be limiting the survival of juvenile chum salmon (WDFW and ODFW 2019). The prevalence of this parasite may increase with warmer water temperatures from flow modification or climatic change. Land development, especially in the low gradient reaches that chum salmon prefer, will continue to be a threat to most chum populations due to projected increases in the [human] population of the greater Vancouver-Portland area and the Lower Columbia River overall (Metro 2014).

Overall, the status of most chum salmon populations is unchanged from the baseline VSP scores estimated in the recovery plan. A total of 3 of 17 populations exceed the recovery goals established in the recovery plan (NMFS 2013a). The remaining populations have unknown abundances, although it is reasonable to assume that the abundances are very low and unlikely to be more than 10 percent of the established recovery goal. Although the Big Creek DIP is currently supported by a hatchery supplementation program, natural origin returns have been very low. Even with the improvements observed during the last five years, the majority of DIPs in this ESU remain at a very high risk level. With so many primary DIPs at near zero abundance, none of the MPGs could be considered viable. The viability of this ESU is relatively unchanged since the NWFSC 2015 report, and the improvements in some populations do not warrant a change in the “moderate to high risk” category described in NWFSC 2015 (see page 200), especially given the uncertainty regarding climatic effects in the near future (Myers, NWFSC, personal communication, May 11, 2022).[9]

LCR Coho Salmon ESU

Overall abundance trends for the ESU are generally negative. Natural spawner and total abundances have decreased in almost all DIPs, and the Coastal and Gorge Strata populations are all at low levels with significant numbers of hatchery-origin coho salmon on the spawning grounds. Some populations were exhibiting positive productivity trends during the last year of review, representing the return of the progeny from the 2016 adult return.

Improvements in diversity and spatial structure have been slight and overshadowed by

[9] The NWFSC viability assessment identified risk category as “moderate” (Ford 2022, Table 1).

declines in abundances and productivity. In light of the poor ocean and freshwater conditions that occurred during much of this recent review period, it should be noted that some of the populations exhibited resilience and only experienced relatively small declines in abundance and even positive productivity trends during the last year of review (2019).

In contrast to the previous 5-year review, which occurred at a time of near record returns for several populations, the ESU abundance has declined during the last five years. Only 6 of the 23 populations for which we have data appear to be above their recovery goals. This includes the Youngs Bay DIP and Big Creek DIP, which have very low recovery goals, and the Salmon Creek DIP and Tilton River DIP, which were not assigned goals but have relatively high abundances. Of the remaining DIPs in the ESU, 3 DIPs are at 50-99% of their recovery goals, 7 DIPs are at 10-50% of their recovery goals, and 7 populations are at less than 10% of their recovery goals (this includes the Lower Gorge DIP for which there are no data, but it is assumed that the abundance is low). Hatchery production has been relatively stable and the proportion of hatchery-origin fish on the spawning grounds has increased for some populations and decreased for others. The transition from segregated hatchery programs to integrated local broodstock programs should reduce the risks from domestication and non-native introgression. Spatial structure has improved incrementally, with improved passage programs at several major dams.

For individual populations, the risk of extinction spans the full range from low to very high. Overall, the Lower Columbia River Coho Salmon ESU remains at moderate risk, and viability is largely unchanged since the last review (Ford 2022).

LCR Steelhead DPS

The majority of winter-run steelhead DIPs in this DPS continue to persist at low abundance levels (100s of fish), with the exception of the Clackamas and Sandy River DIPs, which have abundances in the low 1,000s. Although the 5-year geometric abundance means are near recovery plan goals for many populations, the recent trends are negative. Summer-run steelhead DIPs were similarly stable, but also at low abundance levels. Summer-run DIPs in the Kalama, East Fork Lewis, and Washougal River DIPs are near their recovery plan goals; however, it is unclear the degree to which hatchery-origin fish contribute to this abundance. The decline in the Wind River summer-run DIP is a source of concern, given that this population has been considered one of the healthiest of the summer-runs. It is not clear whether the declines observed represent a short-term oceanic cycle, longer-term climatic change, or other systematic issues. While other species in the Lower Columbia River have a coastal-oriented distribution, steelhead are wide ranging, and it is more difficult to predict the effects of changes in ocean productivity. Alternatively, most steelhead juveniles remain in freshwater for two years prior to emigration, making them more susceptible to climatic changes in temperature and precipitation.

Both summer and winter-run MPGs in the Gorge were well below recovery goals. Although the situation in the Cascade Stratum is better, improvements in fish passage/collection need to be realized in the Upper Cowlitz, North Fork Toutle, and North Fork Lewis rivers to achieve recovery goals. Spatial structure and abundances are limited due to migrational blockages in the Cowlitz and Lewis River basins. The efficiency of adult passage and juvenile collection programs remains an issue. Recent studies indicate that there have been improvements in juvenile collection efficiency at the Cowlitz Falls Project, but these have not been reflected yet in adult abundance. The juvenile collection facilities in the Clackamas River at North Fork Dam appear to be successful enough to support increases in abundance. Hatchery interactions remain a concern in select basins, but the overall situation is somewhat improved compared to prior reviews. It is not possible to determine the risk status of the Gorge MPG given the uncertainty in abundance estimates for nearly half of the DIPs. Additionally, nearly all of the DIPs for which there is abundance data are exhibiting a negative abundance trend in 2018 and 2019.

Overall, the viability trend for the Lower Columbia River Steelhead DPS remains unchanged since the previous (2015) review. While a number of DIPs exhibited increases in their 5-year geometric mean, others still remain depressed, and neither the winter nor summer-run MPGs are near viability in the Gorge. Given these concerns, the Lower Columbia River Steelhead DPS is at a moderate risk of extinction (Ford 2022).

2.3.2 ESA Listing Factor Analysis

Section 4(a)(1) of the ESA directs us to determine whether any species is threatened or endangered because of any of the following factors: (A) the present or threatened destruction, modification, or curtailment of its habitat or range; (B) overutilization for commercial, recreational, scientific, or educational purposes; (C) disease or predation; (D) the inadequacy of existing regulatory mechanisms; or (E) other natural or man-made factors affecting its continued existence. Section 4(b)(1)(A) requires us to make listing determinations after conducting a review of the status of the species and taking into account efforts to protect such species. Below we discuss new information relating to each of the five factors as well as efforts being made to protect the species.

Listing Factor A: Present or threatened destruction, modification or curtailment of its habitat or range

Current Status and Trends in Habitat

Significant habitat restoration and protection actions at the federal, state, and local levels have been implemented to improve habitat conditions and restore fish passage at specific locations. While these efforts have been substantial and are expected to benefit the survival and productivity of the targeted populations, we do not yet have evidence demonstrating that improvements in habitat conditions have led to improvements in population viability. The effectiveness of habitat restoration actions and progress toward meeting the viability criteria should continue to be monitored and evaluated. Generally, it takes one to five decades to demonstrate such increases in viability. Meanwhile, system-wide habitat is affected by unfavorable water temperatures, inadequate volume, modified flow regimes, curtailed habitat complexity and reduced floodplain connectivity, degraded water quality, and poor riparian conditions. In the marine environment, climate change appears to be shifting sea temperatures, salinity, and acidity, each of which separately and in combination may be disruptive to prey species' presence and abundance. Climate concerns are addressed in Section 2.3.2: Listing Factor E: Other natural or manmade factors affecting its continued existence.

Below, we summarize information on the **current status and trends in habitat** conditions since our last 2016 5-year review by the major population groups (MPGs) or population strata comprising the four listed species in the Lower Columbia River.

- **Coast MPGs:** LCR Chinook salmon, CR Chum salmon, and LCR coho salmon (Table 5)
- **Cascade MPGs:** LCR Chinook salmon, CR Chum salmon, LCR coho salmon, and LCR steelhead (Table 6)
- **Gorge MPGs:** LCR Chinook salmon, CR Chum salmon, LCR coho salmon, and LCR steelhead (Table 7)

We specifically address: **(1)** the **key emergent or ongoing habitat concerns** (threats or limiting factors) focusing on the top concerns that potentially have the biggest impact on independent population viability; **(2)** the **population-specific geographic areas of habitat concern** (e.g., independent population major/minor spawning areas) where key emergent or ongoing concerns about this habitat condition remain; **(3) population-specific key protective measures and major restoration actions taken since the 2016 5-year review** toward achieving the recovery plan viability criteria established by the WLCTRT and ODFW (2006) and adopted by NMFS in the ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead (NMFS 2013a) as efforts that substantially address a key concern noted in **above #1 and # 2**, or, that represent a noteworthy conservation strategy; **(4) key regulatory measures that are either adequate, or, inadequate** and contributing substantially to the key concerns summarized above; **(5) recommended future recovery actions over the next five years toward achieving population viability**, including: key near-term restoration actions that would address the key concerns summarized above; projects to address monitoring and research gaps; fixes or initiatives to address inadequate regulatory mechanisms, and addressing priority habitat areas when sequencing priority habitat restoration actions.

(1) Key emergent or ongoing habitat concerns since the 2016 5-year review

Degraded Water Quality

Degraded water quality is an ongoing habitat concern for **all populations and all MPGs comprising the four listed species in the Lower Columbia River:** CR chum salmon, LCR Chinook salmon, LCR steelhead, and LCR coho salmon. All salmon and steelhead species pass through the lower Columbia River as they migrate up or down the mainstem. Toxic contamination arises through the production, use, and disposal of numerous chemicals from multiple sources. Sources include industrial, agricultural, medical/pharmaceutical, and common household uses that enter the Columbia River in wastewater treatment plant effluent, stormwater runoff, and nonpoint source pollution. The mainstem Columbia River is impaired sporadically in Washington by some contaminants, and upstream areas that are impaired contribute toxic pollutants to the downstream reaches (EPA 2020). For example, as reported by EPA 2020, nearly the entire river from McNary Dam to the mouth of the estuary is impaired by more than one toxic pollutant:

- Most of the lower Columbia River mainstem from the Willamette River confluence to the mouth of the estuary is impaired by inorganic arsenic.
- The estuary is impaired by DDT and PCBs from the mouth of the Kalama River to the Ocean.
- The Columbia River estuary below Puget Island is impaired for methylmercury.

Reduced Habitat Complexity, Connectivity, Quantity, and Quality

Reduced complexity, connectivity, quantity, and quality of habitat used for spawning, rearing, foraging, and migrating continues to be a concern for **all populations and all MPGs comprising the four lower Columbia River listed species** in the lower tributaries and tributary/Columbia River mainstem interface, the mainstem (especially for ocean-type Chinook salmon and chum salmon), and the estuary (Marcoe and Pilson, 2017). Lack of access into historically accessible floodplain habitats affects all lower Columbia River ESUs and DPS and continues to be particularly problematic for the full expression of juvenile coho salmon and Chinook salmon life history types (Bottom et al. 2005; NMFS 2013a). The Lower Columbia Fish Recovery Board (LCFRB)[10] notes this is a particular concern for rearing requirements of chum salmon populations across all MPGs), citing that lower river areas are lost to diking to convert bottom lands to agriculture and development, such that braided deltas and complex river mouths have been simplified to single thread systems.

Impaired Mainstem Migratory Corridor and Juvenile Rearing Habitat

Impairment of mainstem migratory corridor and juvenile rearing habitat by ship wake stranding is an emerging concern in the Lower Columbia River, affecting **all populations and all MPGs comprising the four lower Columbia River listed species** (NMFS 2013a). Ship wake stranding is caused when the wake from passing vessels captures and transports juvenile salmonids and other small fish onto beaches where they may perish. This stranding is of particular concern for outmigrating subyearling Chinook salmon, which tend to travel close to shore (Tiffan et al. 2006; Pearson and Skalski 2011) where they are at greater risk of entrainment, and juvenile chum due to their small size as outmigrants (PNNL 2006).

Mainstem Channel Habitat Complexity continues to be a habitat concern for **all populations and all MPGs comprising the four lower Columbia River listed species**. Because the lower Columbia channel serves as migration for both juveniles and adults of every LCR species, conditions within the channel influence all populations. Some LCR Chinook salmon, coho, and steelhead populations have rearing lifestages in the lower Columbia River. Channel conditions are a significant factor in survival and abundance of those species during their juvenile lifestages. Impaired habitat conditions include:

- lack of shallow water habitat and habitat complexity because of more than 100 years of navigational dredging deepening the river from its original 17-foot depth to create a navigation channel with a current depth of greater than 40 feet;

[10] Pers. Comm. Steve Manlow, Executive Director of LCFRB.

- presence of mid-channel islands constructed of dredged material creating habitat for avian predators (See Listing Factor C for additional information on predation);
- multiple in-river dredge disposal sites; and
- presence of more than 200 pile dikes that interrupt fish migration pathways.

(2) Population-specific Geographic Areas of Habitat Concern

Below we list the MPG-specific habitat concerns for each population comprising the four lower Columbia River listed species (LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead). Each population is color-coded to reflect the 2015-2019 5-year geometric mean of raw natural-origin spawner abundances as the relative proportion of the recovery plan abundance target currently obtained for each population (Ford 2022).

Coast MPGs

Table 6. Relative proportion of the 2013 LCR Recovery Plan Abundance Target Achieved for Lower Columbia River Species Independent Populations in the Coast MPGs.

% Recovery Abundance Target Achieved	LCR Chinook Salmon	LCR Coho Salmon	CR Chum Salmon
< 10%	Big Creek Fall (OR) Clatskanie R. Fall (OR) Elochoman/Skamokawa Fall (WA) Mill/Abernathy/Germany Creek Fall (WA)	Grays/Chinook R. (WA) Clatskanie River (OR)	Youngs Bay (OR) Big Creek (OR) Elochoman/Skamakowa (WA) Clatskanie (OR) Mill/Abernathy/Germany Creek (WA) Scappoose Creek (OR)
10>x<50%	Grays/Chinook R. Fall (WA) Youngs Bay Fall (OR)	Elochoman/Skamokawa (WA) Scappoose Creek (OR)	
50>x<100%		Mill/Abernathy/Germany Creek (WA)	
>100%		Youngs Bay (OR) Big Creek (OR)	Grays/Chinook River (WA)

Colors indicate the relative proportion of the recovery target currently obtained: red (<10%), orange (10>x<50%), yellow (50>x<100%), green (>100%). Summarized from NWFSC (2022).

The following habitat concerns affect salmonids in the Coast MPGs.

Insufficient Forest Cover/Riparian Condition: Impairment of shade/thermal input, detrital prey source, and recruitment of large woody debris diminish spawning and rearing conditions for all populations. Canopy species greater than 5 meters in height have declined from 74 percent to 58 percent in the Grays River subbasin and from 79 percent to 56 percent in the Estuary Tributaries subbasin when National Land Cover Dataset data is compared for the years 2001 and 2016 (LCFRB, personal communication, November 13, 2020).

Insufficient (low) flows: Impairment of early adult spawning migration affects all fall Chinook salmon populations - Grays/Chinook River (WA), Youngs Bay (OR), Big Creek (OR), Elochoman/Skamokawa (WA), Clatskanie River (OR), and Mill/Abernathy/Germany Creek (WA).

High Sediment Load: Sediment loads impair (1) spawning habitat for Grays/Chinook River chum, and (2) side channel/pool rearing habitat for Grays/Chinook River coho.

"Flashy" Streamflows: Altered flows impair spawning habitat for Grays/Chinook River chum, Grays/Chinook River fall Chinook salmon, and Grays/Chinook River coho.

Diminished Habitat Complexity: Reduced habitat complexity impairs summer and winter rearing habitat for Mill/Abernathy/Germany Creek populations of coho.

Cascade MPGs

Table 7. Relative proportion of the 2013 LCR Recovery Plan Abundance Target Achieved for Lower Columbia River Species Independent Populations in the Cascade MPGs.

% Recovery Abundance Target Achieved	LCR Chinook Salmon	LCR Coho Salmon	CR Chum Salmon	LCR Steelhead
< 10%	Toutle R Spring (WA) Upper Cowlitz R. Spring (WA) Cispus R. Spring (WA) Tilton R. Spring (WA) NF Lewis R. (WA) Toutle R. Fall (WA)	Cispus R. (WA) Kalama R. (WA) Clackamas R. (OR)	Cowlitz R Summer (WA) Cowlitz R Fall (WA) Kalama R. (WA) Lewis R. (WA) Salmon Cr. (WA) Clackamas R. (OR) Sandy R. (OR)	Lower Cowlitz R. Winter (WA) Cispus R. Winter (WA) NF Lewis R. Summer (WA) Salmon Cr. Winter (WA)
10>x<50%	Kalama R. Spring (WA) Clackamas R. Fall (OR) Sandy R. Late Fall (OR)	Upper Cowlitz R. (WA) NF Toutle R. (WA) EF Lewis R. (WA) Sandy R. (OR) Washougal R. (WA)		NF Toutle R. Winter (WA)* Upper Cowlitz R. Winter (WA) Clackamas R. Winter (OR)
50>x<100%	Coweeman R. Fall (WA) Washougal R. Fall (WA)	Lower Cowlitz R. (WA) SF Toutle R. (WA)		
>100%	Sandy R. Spring (OR) Sandy R. Fall (OR) Lower Cowlitz R. Fall (WA) Kalama R. Fall (WA), Lewis R. Fall (WA), NF Lewis R. Late Fall (WA)	Coweeman R. (WA) Tilton R. (WA) NF Lewis R. (WA) Salmon Cr. (WA)	Washougal R. (WA)	Tilton R. Winter (WA) Sandy R. Winter (OR) Coweeman R. Winter (WA)* SF Toutle R. Winter (WA)* Kalama R. Summer (WA)* EF Lewis R. Summer (WA)* Washougal R. Winter (WA)*

% Recovery Abundance Target Achieved	LCR Chinook Salmon	LCR Coho Salmon	CR Chum Salmon	LCR Steelhead
				Kalama R. Summer (WA)* EF Lewis R. Summer (WA)* Washougal R. Summer (WA)*

Colors indicate the relative proportion of the recovery target currently obtained: red (<10%), orange (10>x<50%), yellow (50>x<100%), green (>100%). Populations with uncertainty in meeting recovery targets are noted with asterisks and represent total (hatchery+natural origin) spawners. Summarized from NWFSC (2022).

The following habitat concerns affect salmonids in the Cascade MPGs.

Insufficient Forest Cover/Riparian Condition: Impaired shade/thermal input, detrital prey source, and recruitment of large woody debris diminish spawning and rearing habitat for the following populations:

Lower Cowlitz fall Chinook salmon, Lower Cowlitz coho, Lower Cowlitz River winter steelhead, Cowlitz River chum.

Toutle River fall Chinook salmon, Toutle River spring Chinook salmon, NF Toutle River coho, SF Toutle River coho, NF Toutle winter steelhead, SF Toutle winter steelhead.

Lewis River chum, EF Lewis River coho, EF Lewis River winter steelhead, EF Lewis River summer steelhead, Lewis River fall Chinook salmon.

Washougal River coho, Washougal River winter steelhead, Washougal River summer steelhead, Washougal River chum, Washougal River fall Chinook salmon.

Clackamas River Fall Chinook salmon, Clackamas River chum, Clackamas River coho, Clackamas River winter steelhead[11].

Chemical Contamination: Mercury, and PCB contamination of the Cowlitz River, and copper contamination in the streams of the Lower Cowlitz River Watershed (EPA 2020) impairs spawning and rearing habitat for Upper Cowlitz spring Chinook salmon, Lower Cowlitz River fall Chinook salmon, Cowlitz River chum, Lower Cowlitz coho, Lower Cowlitz winter steelhead, and Upper Cowlitz winter steelhead.

Organochlorine insecticide, including Aldrin and/or Dieldrin, contamination in the Sandy River (EPA 2020) impairs spawning and rearing habitat for Sandy River spring Chinook, Sandy River fall Chinook, Sandy River chum, Sandy River coho, and Sandy River winter steelhead.

[11] The 2020 Riverside Fire further aggravated the impaired spawning and rearing habitat of the Oregon Clackamas populations by increasing the risk of debris and sediment load for theses populations.

DDT contamination of the Kalama River (EPA 2020) impairs spawning, rearing, and migration habitat for Kalama River spring Chinook salmon, Kalama River fall Chinook, Kalama River chum, Kalama River coho, Kalama River winter steelhead, and Kalama River summer steelhead.

Excessive Stream Temperature: High stream temperatures diminish cold-water refugia for all listed salmonid populations within the Cascade MPG.

Diminished Habitat Complexity and Floodplain Connectivity Loss to Land Conversion for Expanding Human Uses: Reduced habitat complexity impairs (1) spawning habitat for Kalama River chum, and (2) rearing habitat for Kalama River fall Chinook salmon, Kalama River coho, Kalama River winter steelhead, and Kalama River summer steelhead.

Exempt Residential Groundwater Withdrawals of up to 5,000 Gallons per Day: Insufficient streamflows in Cowlitz County and Clark County impair spawning and rearing habitats in the North and East Forks Lewis River and other streams for NF Lewis River winter steelhead, NF Lewis River summer steelhead, Lewis River chum, Lewis River Fall Chinook salmon, NF Lewis River coho, NF Lewis River spring Chinook salmon, NF Lewis River Late Fall Chinook salmon, EF Lewis River coho, EF Lewis River winter steelhead, EF Lewis River summer steelhead.

Impaired Passage/Upstream Habitat Access:

> PacifiCorp dams on the North Fork Lewis River affect spatial distribution of NF Lewis Spring Chinook salmon, NF Lewis River winter steelhead, and NF Lewis River coho. Fish trap and haul transports fish past two reservoirs and releases fish into the uppermost reservoir only. Access to upstream habitat in the Lewis River Basin remains a major limitation to LCR spring Chinook salmon spatial structure in the Cascade MPG.
>
> Mayfield, Mossyrock and Packwood dams affect Upper Cowlitz River spring Chinook salmon, as well as steelhead, coho, and maybe even summer chum. Collection and transport have not attained efficiency to create self-sustaining populations of LCR spring Chinook salmon, and access to upstream habitat in the Cowlitz River basin remains a major limitation to LCR spring Chinook salmon spatial structure in the Cascade MPG.
>
> The Mount Saint Helens Sediment Retention Structure on the Toutle River obstructs passage. A fish trap structure to capture and transport fish upstream of sediment structure has a high mortality rate and was found to jeopardize SF Toutle River winter steelhead and NF Toutle River and SF Toutle River coho in a 2017 biological opinion (NMFS 2017b). The Reasonable and Prudent Alternative identified in the biological opinion has not yet been implemented.

Gorge MPGs

Table 8. Relative proportion of the 2013 LCR Recovery Plan Abundance Target Achieved for Lower Columbia River Species Independent Populations in the Gorge MPGs.

% Recovery Abundance Target Achieved	LCR Chinook Salmon	LCR Coho Salmon	CR Chum Salmon	LCR Steelhead
< 10%	White Salmon R-Spring (WA) Hood R-Spring (OR) Hood R-Fall (OR)	Lwr Gorge (WA & OR) Upr Gorge/White Salmon R. (WA) Upr Gorge/Hood R. (OR)	Upr Gorge-Fall (WA & OR)	Lwr Gorge-Winter (WA & OR) Upr Gorge-Winter (Wind R. WA) Hood River-Summer (OR)
10>x<50%	Upr Gorge-Fall (WA & OR) White Salmon R-Fall (WA)			Hood R-Winter (OR)
50>x<100%				Wind River-Summer (WA)
>100%	Lwr Gorge-Fall (WA & OR)		Lwr Gorge-Fall (WA & OR)	

Colors indicate the relative proportion of the recovery target currently obtained: red (<10%), orange (10>x<50%), yellow (50>x<100%), green (>100%). Summarized from Ford (2022).

The following habitat concerns affect salmonids in the Gorge MPGs.

Excessive Stream Temperature: High stream temperatures impair cold water refugia for Lower Gorge (Woodard Creek) LCR fall Chinook salmon, Upper Gorge (Wind River and White Salmon rivers) LCR fall Chinook salmon, Lower Gorge (Woodard Creek) winter steelhead, Upper Gorge (Wind River) steelhead, and Wind River summer steelhead.

Excess Winter Flow: High streamflows impair spawning habitat for Lower Gorge chum and Upper Gorge chum.

Limited Channel Complexity: Reduced channel complexity impairs juvenile rearing habitat for Wind River summer steelhead.

Degraded Riparian Conditions and Excess Sediment Loading/Debris Flow from the 2017 Eagle Creek Fire: Degraded riparian conditions and excess sediment impair spawning and rearing habitat for Upper Gorge (Wind River) winter steelhead, Lower Gorge coho, Lower Gorge chum, and Lower Gorge Fall Chinook salmon.

(3) Population-specific key protective measures and major restoration actions taken since the 2016 5-year review

In the 2016 5-year review, NMFS made a suite of recommendations for future actions, including actions for each of the four "Hs" of salmon recovery: habitat, hatcheries, harvest, and hydropower, plus a few general recommendations. For habitat, we recommended continuing habitat restoration, particularly in high priority areas identified in the 2013 recovery plan (NMFS 2013a).

Specifically, we made the following recommendations regarding habitat in 2016:

- Continue to implement and record priority habitat actions in accordance with the 2013 recovery plan (NMFS 2013a).
- Systematically review and analyze the amount of habitat protected/restored against those high priority lower Columbia River mainstem and tributary areas identified in the 2013 Recovery Plan (NMFS 2013a).
- Incorporate mechanisms of salmonid density-dependent growth, dispersal, and survival when selecting habitat restoration actions as an approach to opening up new habitat and/or restoring degraded habitat (ISAB 2015).

Since 2016, a diverse suite of habitat protection and restoration actions in the geography of the Coast, Cascade, and Gorge MPGs were completed. However, the specific process described in the third bullet may not have been utilized when selecting habitat restoration actions.

<u>Coast MPGs</u>

Since the 2016 review, habitat and population gains are expected from nine completed habitat restoration and conservation projects, and six additional projects being implemented in the Grays River watershed. Chum channel construction is also occurring to support future spawning for Elochoman-Skamokawa chum through Washington Department of Fish and Wildlife (WDFW) work funded via the Washington Department of Ecology via their Office of the Columbia River grant program.

Since 2016, four restoration projects and one acquisition project have been completed in the Estuary Tributaries subbasin. Additional completed projects include six restoration and three acquisition projects in the Grays River (Grays/Chinook River coho, Grays/Chinook River chum, Grays/Chinook River fall Chinook salmon), seven restoration projects in the Elochoman-Skamokawa subbasin (fall Chinook salmon, chum, coho), and eleven restoration and one acquisition projects in the Mill-Abernathy-Germany subbasin (coho, fall Chinook salmon, chum). Active restoration projects include one in the Estuary Tributaries, six in the Grays River, ten in the Elochoman-Skamokawa subbasin, and three in the Mill-Abernathy-Germany Creek subbasin. Combined, completed projects resulted in 18.5 miles of newly accessible stream habitat, 856 acres of nearshore habitat treated, 230 acres of riparian treated along 52 miles of streambank, and 48 miles of stream habitat treated and/or protected. Combined, completed projects resulted in 18.5 miles of newly accessible stream habitat, 856 acres of nearshore habitat treated, 230 acres of riparian treated along 52 miles of streambank, and 48 miles of stream habitat treated and/or protected (LCFRB 2020a).

Additionally, 67 projects (31 percent of identified restoration needs) were completed in regional stream reaches that have presumed winter steelhead presence benefiting all lifestages; 59 projects (29 percent of identified restoration needs) were completed in regional stream reaches that have presumed coho salmon presence.

In Oregon, two culverts were replaced in 2018 and 2019 improving passage for Youngs Bay Fall Chinook salmon, Youngs Bay chum, Youngs Bay coho, and, two replaced culverts improved passage for Clatskanie River fall Chinook salmon, Clatskanie chum, and Clatskanie River coho.

Cascade MPGs

The LCFRB (personal communication, November 13, 2020) reported the completion of the following restoration and conservation projects since 2016:

- Five restoration projects in the Lower Cowlitz River (fall Chinook Salmon, coho, and winter steelhead);
- One restoration project in the Upper Cowlitz River (spring Chinook salmon, fall Chinook salmon and coho);
- One restoration project in the Cispus River (spring Chinook salmon, winter steelhead, and coho);
- Twenty-three restoration projects in the Toutle River (spring Chinook salmon, fall Chinook salmon, NF Toutle River winter steelhead, SF Toutle River winter steelhead; NF Toutle River coho, and SF Toutle River coho);
- Five restoration and one acquisition projects in the Kalama River (summer and winter steelhead, chum, spring Chinook salmon);
- Seven restoration projects in the Coweeman River (fall Chinook salmon, winter steelhead, and coho);
- Five restoration projects in the North Fork Lewis River (coho, spring Chinook salmon, late fall Chinook salmon, summer steelhead, winter steelhead);
- Three restoration and one acquisition projects in the East Fork Lewis River (fall Chinook salmon, winter steelhead, summer steelhead);
- Three restoration and two acquisition projects in Salmon Creek (fall Chinook salmon, chum, winter steelhead); and
- Seven restoration projects (fall Chinook salmon, chum, summer steelhead, coho) in the Washougal River.

Almost half of these projects (31) are fish passage improvement projects completed as part of the Washington Department of Natural Resource's Road Maintenance and Abandonment Plan (RMAP) program that created 38 miles of newly accessible stream habitat. The remaining projects enhanced or provided access to 58 acres of nearshore habitat treated, 97 acres of riparian treated along 39 miles of streambank, and 127 miles of stream habitat treated and/or protected (LCFRB 2020b).

The Steigerwald Floodplain Restoration Project along the banks of the Columbia River near Washougal, Washington was initiated in the summer of 2020. Upon completion in April 2022, this project will reconnect 965 acres of Columbia River floodplain habitat (LCEP 2020), benefiting all upstream populations from the Cascade and Gorge MPGs species/populations. One project component, the Gibbons Creek Restoration completed in 2020, intends to restore chum access to Gibbons Creek.

Clark Public Utilities completed the first phase of its new Paradise Point regional water supply system in July 2020, addressing a high priority instream flow improvement action in the WRIA 27/28 plan. This project has transitioned 7.2 million gallons of water withdrawals away from the aquifer that serves the Lewis River watershed (where temperature and flow limitations impact salmon habitat) to the aquifer that serves the mainstem Columbia River. It is anticipated that East Fork Lewis River base summer flows will increase by 3.1 cubic feet per second due to this water supply revision.

A chum spawning channel construction project is in preparation at Eagle Island in the Lewis River. The Eagle Island project is similar to the Skamokawa and Crazy Johnson chum spawning channel construction projects, both completed in the summer of 2017. These projects benefit sub populations of the Lewis River chum population.

In 2019 Oregon habitat restoration on the Sandy River included a culvert replacement, 9 miles of large wood placement, 1 mile of riparian planting, and 5.2 miles of side-channel creation. The projects benefit Sandy River spring Chinook salmon, Sandy River fall Chinook salmon, Sandy River late fall Chinook salmon, Sandy River chum, Sandy River coho, Sandy River winter steelhead.

Since the 2013 removal of the Sandy River Delta Dam, the mainstem Sandy River has been undammed for 56 river miles from the headwaters to the confluence, with a more natural flow regime, increased floodplain connectivity, and channel complexity. In 2018, 854 volunteers planted more than 5,200 regionally native trees and shrubs at the delta.

In 2018, the Portland Water Bureau, the Mt. Hood National Forest (U.S. Forest Service [USFS]), and ODFW continued collaboration on a long-term study, monitoring steelhead and coho smolt production throughout the Sandy River basin in Oregon. Monitored smolt production was moderate to relatively high for steelhead and coho in 2018. The Salmon River had the highest number of both steelhead and coho smolts of any streams monitored in 2018. The Salmon River and Beaver Creek both produced more steelhead smolts in 2018 than in any previous monitored year. Steelhead have increased significantly in the Salmon River, Little Sandy River, and the Bull Run River. Coho have increased significantly in Still Creek, but decreased significantly in Beaver Creek (http://www.nwp.usace.army.mil/Missions/Current/SandyRiverDelta.aspx). However, 2020 saw wildfires that included evacuation advisories in the Sandy Area, which likely impaired riparian conditions and risk of increased sediment load.

Gorge MPGs

Since the 2016 5-year review, four projects have been completed benefiting the gorge strata, and another three are currently active (Salmon Recovery Portal[12]): one acquisition and one restoration project in the Lower Gorge Tributaries and one RMAP project in the Wind River subbasin, benefiting fall Chinook salmon, coho, chum, winter steelhead and summer steelhead) (Salmon Recovery Portal). Combined, these projects resulted in 2 miles of newly accessible stream habitat, 35.5 acres of riparian habitat treated along 1.9 miles of streambank, and 2.8 miles of stream habitat treated and/or protected. These projects are located in stream reaches upstream of chum habitat. However, they are expected to support and benefit downstream watershed processes.

Also, since 2016, 17 projects (8 percent of identified restoration needs) were completed in regional stream reaches that have presumed summer steelhead presence.

In Oregon, Hood River restoration activities in 2018 and 2019 included three culvert replacements, 2.1 miles of large wood emplacement, and conservation of 1.0 cubic feet per second stream flow via eight irrigation improvement projects. These projects benefit Hood River fall Chinook salmon, Hood River spring Chinook salmon, Upper Gorge/Hood River coho, Hood River winter steelhead, Hood River summer steelhead.

(4) Key regulatory measures since the 2016 5-year review

Various federal, state, and county regulatory mechanisms are in place to minimize or avoid habitat degradation caused by human use and development. New information available since the last 5-year review indicates that the adequacy of many regulatory mechanisms has stayed the same on average, with some mechanisms showing the potential for some improvement. Others have made it more challenging to protect and recover our species. *See Listing Factor D: Inadequacy of Regulatory Mechanisms Efforts* in this document for details.

(5) Recommended future recovery actions over the next five years toward achieving population viability

For all populations and all strata that comprise the four listed species in the Lower Columbia River – CR chum salmon, LCR Chinook salmon, LCR steelhead, and LCR coho salmon- recommended future recovery actions over the next five years include:

- Conduct monitoring to evaluate ship wake stranding frequency and locations where stranding occurs and assess factors contributing to wake stranding such as location, topography, vessel speed, et cetera, to determine best practices to reduce wake stranding mortality.

[12] The Salmon Recovery Portal is a mapping and project tracking tool managed by the Washington State Recreation and Conservation Office (https://srp.rco.wa.gov).

- Promote riparian plantings of native canopy tree cover species opportunistically in all watersheds.

- Coordinate with EPA in an evaluation of Washington State water quality standards, reflecting Oregon and Idaho ESA Section 7 consultation outcomes.

- Increase the number of habitat projects that target fall Chinook salmon spawning (Big Creek, Elochoman/Skamokawa, Clatskanie River, Mill/Abernathy/Germany Creek, Toutle River, and Hood River).

- Apply results from the Lower Columbia Intensively Monitored Watershed study of Mill, Abernathy, and Germany creeks - a Before-After-Control-Impact Design study which assessed how restoration influenced salmon and steelhead abundance (WDFW 2012) to future restoration efforts targeting coho salmon, to improve habitat restoration methods across all MPGS and promote the abundance of this species.

<u>In the Coast MPGs:</u>

- Increase the number of projects that reduce sediment load in spawning habitat for Grays/Chinook River chum,

- Implement projects that increase the amount of side channel/pool rearing habitat for Grays/Chinook River coho.

- Promote projects that reduce flashy stream conditions to improve spawning habitat for Grays/Chinook River chum, Grays/Chinook River fall Chinook salmon, and Grays/Chinook River coho.

- Implement projects to increase summer and winter rearing Habitat Complexity for Mill/Abernathy/Germany Creek coho.

- Implement additional habitat improvement projects in the Elochoman River and Abernathy, Mill, and Germany creeks, and their tributaries to augment spawning (chum) and rearing (coho) habitat.

<u>In the Cascade MPGs:</u>

- Reestablish and improve passage on multiple rivers to benefit multiple populations from the Cascade MPGs, such as the North Fork Lewis River (NF Lewis River spring Chinook, NF Lewis River winter steelhead, NF Lewis River coho), and Cowlitz River (Upper Cowlitz River spring Chinook, Upper Cowlitz River fall Chinook, Upper Cowlitz River coho, Upper Cowlitz River winter steelhead).

- Identify and implement spawning habitat projects to expand spatial distribution of chum into the Cascade MPG, with priority on the Lewis and Washougal rivers (Washington Primary populations) and the Cowlitz and Kalama rivers (contributing populations).

- Work with county and city jurisdictions to protect watershed hydrology from long-term development impacts (floodplain development and groundwater withdrawals). Focus these efforts on high growth rate watersheds along the I-5 and I-205 corridors including the East Fork Lewis River, North Fork Lewis River, Coweeman River, Kalama River, Washougal River, Salmon Creek, and Lower Cowlitz Tributaries.

In the Gorge MPGs:

- Continue to work with partners on programs protecting instream and floodplain habitats in key chum spawning areas (e.g., Duncan Creek, Hamilton Creek).

- Evaluate if large wood debris mitigates excess winter stream flows that degrade spawning for Upper Gorge chum).

- Continue to work with partners to identify suitable chum spawning habitat streams and reaches to emplace habitat creation or enhancement projects in order to expand spatial distribution into the gorge strata.

- Improve understanding of key factors limiting recovery by evaluating summer run gorge steelhead losses between Bonneville Dam and Shipherd Falls.

- Implement the EPA 2021 Columbia River Cold Water Refuges Plan, for example in Woodard Creek to benefit, Upper Gorge (Wind River and White Salmon rivers) LCR fall Chinook salmon, Lower Gorge (Woodard Creek) winter steelhead, Upper Gorge (Wind River) steelhead, and Wind River summer steelhead.

- Implement habitat projects to mitigate excess winter flow to improve spawning habitat for Lower Gorge chum and Upper Gorge chum.

- Increase channel complexity to improve juvenile rearing habitat for Wind River summer steelhead.

Listing Factor A Conclusions

New information available since the last 5-year review indicates improved habitat and fish passage conditions at specific sites within the geography of the Cascade, Coast, and Gorge MPGs of all four listed species. These improvements are due to restoration, acquisition, and conservation work since the last 5-year review in freshwater and estuary habitat areas. These restoration projects should improve survival for some populations within the lower Columbia River ESUs/DPS, resulting in future population gains and enhanced resiliency.

However, for listed LCR species, climate change is an overarching emergent concern and degraded water quality, insufficient floodplain connectivity, habitat complexity, and ship wake stranding are ongoing concerns. For the Coast MPG of all three species, insufficient forest cover and riparian conditions remain ongoing concerns.

At this time, we do not have information that would reveal overall trends in habitat quality, quantity, and function. Future status assessments would benefit from a systematic review and analysis of high priority Lower Columbia River mainstem and tributary area habitat needs, identified in the 2013 recovery plan (NMFS 2013a), and a comparison of needs to what has been accomplished. Despite multiple ongoing restoration efforts that have addressed site-specific conditions, we remain concerned about systemically degraded habitat conditions.

Within the Coast MPGs all 6 CR chum salmon populations are at less than 10 percent of their recovery plan target abundance; of 7 coho populations, only 2 exceed full abundance targets (Young's Bay and Big Creek); and of the 6 Chinook salmon populations, no population exceeds 50 percent of the target abundance. Current habitat conditions in these MPGs are insufficient for recovery of 17 of the 19 independent populations, particularly so for chum.

Within the Cascade MPGs, 6 of the 7 CR chum populations are at less than 10 percent of their recovery plan target abundance, but the Washougal population is exceeding the abundance target. Of 17 coho populations, 9 are above 50 percent of their target populations and of these 4 exceed full abundance targets (Coweeman, Tilton, NF Lewis, and Salmon Creek). Of the 17 Chinook populations, 6 are at less than 10 percent of target abundance and 6 are exceeding their full target abundance. Of 19 steelhead populations in this MPG, 10 populations are exceeding full target abundance, but 8 of these abundance estimates are confounded by an unknown contribution of hatchery-origin spawners. Abundance estimates for the Tilton and Sandy River winter runs are based on reliable data. Overall, habitat conditions in the Cascade MPGs currently support the recovery of only half of the MPG's populations.

Within the Gorge MPGs, one chum population is less than 10 percent of the abundance target, but the other exceeds the target abundance. All three coho populations are at less than 10 percent of their target abundance. Of the 6 Chinook populations in this MPG, 5 are at less than 50 percent of the target abundance (3 of these at less than 10 percent), and only 1 exceeds full abundance target (Lower Gorge Spring Run). Of 5 steelhead populations, 3 are at less than 10 percent of their target and only one population is between 50 and 100 percent of the target abundance. Habitat conditions within the Gorge MPGs currently only support achieving recovery for 3 of the MPG's 16 populations.

Throughout the range of the LCR Chinook Salmon ESU, the LCR Coho ESU, the CR Chum ESU and the LCR Steelhead DPS, channel complexity, side channel and floodplain connectivity, water quality and quantity, and riparian cover remain in poor condition. There is need for habitat restoration or protection throughout the range of these species. Additional habitat protection and restoration actions are necessary to bring these ESUs/DPS to viable status.

In our previous 5-year review, we acknowledged that there have been improvements in freshwater and estuary habitat conditions, improved fish passage, and numerous tributary habitat restoration efforts that over time should yield improved survival for LCR ESUs/ DPSs (NMFS

2016a). However, we cautioned that at the time, we did not have sufficient information to reveal overall trends in habitat quality, quantity, and function (NMFS 2016a). We continue to have insufficient information to assess lower Columbia River habitat trends in detail. We note that ongoing large-scale trends in the lower Columbia River are towards the degradation of habitat due to ongoing development and human use. Site-specific restoration actions taken since the previous 5-year review are having positive effects but are not sufficient to rectify the overall trend towards declining habitat conditions. We continue to remain concerned about degraded habitat conditions in the lower Columbia River. We conclude that risks to the persistence of LCR Chinook Salmon ESU, LCR Coho ESU, CR Chum ESU, and LCR Steelhead DPS remain because habitat destruction and modification is increasing.

Listing Factor B: Overutilization for commercial, recreational, scientific, or educational purposes

Harvest

Systematic improvements in fisheries management since the last 5-year review include:

- Implementation of a newly negotiated 2019 Pacific Salmon Treaty, which has reduced impacts to fall-run Chinook salmon in fisheries that occur north of the US/Canada border on average by cutbacks of 7.5 percent in Alaska and 12.5 percent in British Columbia beginning in 2020. Those restrictions reduce catches beyond earlier cutbacks in 2009 of 15 percent in Alaska and 30 percent in British Columbia. There has not been an increased rate of salmon fishing in northern areas of the Pacific West Coast for the past 20 years.
- Implementing an updated ABM matrix on LCR coho salmon beginning in 2015. Implementation of the new harvest matrix includes tracking ten primary coho salmon populations in the ESU whereas the previous matrix only tracked two (NMFS 2015a).
- Implementation of the *U.S. v. Oregon* Management Agreement (in effect through 2027), which will maintain harvest impacts reductions secured in previous agreements on the ESUs/DPS (NMFS 2018b).
- Implementation of increased mark-selective fisheries for both coho and Chinook salmon, both recreational and commercial, which has contributed to reduced numbers of hatchery-origin spawners (WDFW 2015).

LCR Chinook Salmon ESU

LCR Chinook salmon include three distinct life-history components: spring-run Chinook salmon, tule fall-run Chinook salmon, and late fall-run Chinook salmon (Ford 2022). These different components are subject to different in-river fisheries because of differences in river entry timing but share similar ocean distributions.

- Harvest of fall-run Chinook salmon between 2015 and 2019 has seen a modest increase from the decreasing trend observed from 2005 through 2012 of 30 and 40 percent harvest rates on the ESU (TAC 2017, 2018, 2019, 2020). As part of this approach, NMFS adopted in its biological opinion an assessment of the performance of the ABM matrix every three years as a check on projected results and any changes in key presumptions. The latest performance review for Chinook salmon was completed in 2019 (NMFS 2019b) concluding new escapement information gathered over the last four or five years shows no substantive changes in abundance or hatchery fractions that are inconsistent with previous trends, and when more data points allow for a more comprehensive review, the estimates of exploitation rates from fishery models should be compared to independent exploitation rate estimates derived from coded-wire tag groups.

- Harvest of late fall-run Chinook salmon also dropped to 20 to 25 percent in the mid-1990s but has been increasing since. In the period from 2015 to 2019, harvest rates of late fall-run Chinook salmon increased, equivalent to the harvest rates between 1985 and 1990 (TAC 2017, 2018, 2019, 2020). These rates for late fall-run Chinook salmon (North Fork Lewis and Sandy populations) are now based on the escapement of natural-origin fish, ensuring that there are sufficient numbers of adults on the spawning grounds.

CR Chum Salmon

CR chum salmon were historically abundant and subject to substantial harvest until the 1950s (Johnson et al. 1997). In recent years, there has been no directed harvest of CR chum salmon (NMFS 2018b). Commercial harvest has been less than 100 fish per year since 1993, and all recreational fisheries have been closed since 1995. The incidental harvest rate on CR chum salmon was 0.3 percent in 2018 (Ford 2022). Overall, the exploitation rate has been below one percent for the last five years (Ford 2022).

LCR Coho Salmon

LCR coho salmon are part of the Oregon Production Index and are harvested in ocean fisheries primarily off the coasts of Oregon and Washington, with some harvest that historically occurred off of the West Coast Vancouver Island (Ford 2022). Canadian coho salmon fisheries were severely restricted in the 1990s to protect upper Fraser River coho salmon and have remained so ever since. Ocean fisheries off California were closed to coho salmon retention in 1993 and have remained closed ever since. Ocean fisheries for coho salmon off of Oregon and Washington were dramatically reduced in 1993 in response to the depressed status of Oregon Coast natural coho salmon and subsequent listing and moved to mark-selective fishing beginning in 1999. LCR coho salmon benefitted from the more restrictive management of ocean fisheries. Overall exploitation rates regularly exceeded 80 percent in the 1980s but have remained below 30 percent since 1993. In addition, freshwater fisheries impacts on naturally produced coho salmon have been markedly reduced through the implementation of selective fisheries. The most recent impact rate for LCR coho salmon was 23.0 percent in 2019 (Ford 2022).

Similar to the approach utilized for Chinook salmon, NMFS adopted a performance assessment every three years in its biological opinion of the coho salmon ABM matrix as a check on projected results and any changes in key presumptions. The latest performance review for coho salmon was completed in 2019 (NMFS 2019c) concluding more data points are needed to allow for a comprehensive review. At that point the review should include comparisons of the estimates of exploitation rates from FRAM to population specific independent exploitation rate estimates derived from coded-wire tag groups that are now being used to track the new status information on the additional populations being monitored. Trends in the proportion of hatchery origin spawners (pHOS) should also be evaluated once more data points associated with the new control rule are available.

LCR Steelhead

Steelhead from this DPS are incidentally intercepted in mainstem treaty, and non-treaty commercial and recreational fisheries targeting non-listed hatchery and naturally produced Chinook salmon, and non-listed steelhead. Mark-selective net fisheries in the mainstem Columbia River can result in post-release mortality rates of 10 to over 30 percent, although there is considerable disagreement on the overall rate. Recreational fisheries targeting marked hatchery-origin steelhead encounter natural-origin fish at a relatively high rate, but hooking mortalities are generally lower than those in the net fisheries. Estimated mortality for naturally produced winter-run steelhead has averaged 0.3 percent (Ford 2022). The current *U.S. v. Oregon* Management Agreement (2018-2027) has, on average, maintained reduced harvest impacts for LCR steelhead fisheries (TAC 2015-19) with 2018 harvest rates for winter-run steelhead in mainstem fisheries at 0.3 percent (TAC 2015), and with harvest rates for unclipped summer-run steelhead of 0.5 percent in fisheries below Bonneville Dam and 0.01 percent in the Bonneville Pool (Ford 2022).

Research and Monitoring

The quantity of take authorized under ESA sections 10(a)(1)(A) and 4(d) for scientific research and monitoring for these species remains low in comparison to their abundance, and much of the work being conducted is done for the purpose of fulfilling state and federal agency obligations under the ESA to ascertain the species' status. Authorized mortality rates associated with scientific research and monitoring are generally capped at 0.5 percent across the West Coast Region for all listed salmonid ESUs and DPSs. As a result, the mortality levels that research causes are very low throughout the region. In addition, and as with all other listed salmonids, the effects research has on the lower Columbia River salmonids are spread out over various reaches, tributaries, and areas across all of their ranges, and thus no area or population is likely to experience a disproportionate amount of loss. Therefore, the research program, as a whole, has only a very small impact on overall population abundance, a similarly small impact on productivity, and no measurable effect on spatial structure or diversity for LCR Chinook salmon, LCR coho salmon, LCR steelhead, or CR chum salmon.

Any time we seek to issue a permit for scientific research, we consult on the effects that the proposed work would have on each listed species' natural- and hatchery-origin components. However, because research has never been identified as a threat or a limiting factor for any listed species, and because most hatchery fish are considered excess to their species' recovery needs, examining the quantity of hatchery fish taken for scientific research would not inform our analysis of the threats to a species' recovery. Therefore, we only discuss the research-associated take of naturally produced fish in these sections.

Database records (NMFS APPS database; https://apps.nmfs.noaa.gov/) show that from 2015 through 2019 researchers were approved to take a yearly average of:

- fewer than 900 naturally produced adult (<28 lethally) and fewer than 1,693,000 juvenile (<17,800 lethally) LCR Chinook salmon per year,

- fewer than 3,500 naturally produced adult (<41 lethally) and fewer than 68,800 juvenile (<1,400 lethally) LCR steelhead per year,
- fewer than 2,600 naturally produced adult (<39 lethally) and fewer than 220,400 juvenile (<3,200 lethally) LCR coho salmon per year, and
- fewer than 64 naturally-produced adult (<14 lethally) and fewer than 28,800 juvenile (<470 lethally) CR chum salmon per year.

For the vast majority of scientific research permits, history has shown that researchers generally take far fewer salmonids than are authorized every year. Reporting from 2015 through 2019 indicates that over those five years, the annual average actual total take for naturally produced juveniles or adults was 24 percent or less of the average yearly amount authorized for LCR Chinook salmon, 29 percent or less of the amount authorized for LCR steelhead, 22 percent or less of the amount authorized for LCR coho, and 16 percent or less of the amount authorized for CR chum salmon. The actual lethal take was also low over the same 5-year period: average yearly lethal take of juveniles ranged from 8-18 percent of the average amount authorized per year across all four species, and average yearly lethal take of adults ranged from 0-11 percent of the average amount authorized per year across all four species.

The majority of the requested take for naturally produced juveniles from all four species has primarily been (and is expected to continue to be) capture via screw traps, electrofishing units, and beach seines, with smaller numbers collected as a result of minnow traps, fyke nets, other seines, hand or dip netting, trawling, hook and line sampling, and those intentionally sacrificed. Adult take for the four species has primarily been (and is expected to continue to be) capture via weirs or fish ladders, hook and line angling, trawling, and hand or dip nets, with smaller numbers getting unintentionally captured by screw traps, seining, and other methods that target juveniles (NMFS APPS database; https://apps.nmfs.noaa.gov/). Our records indicate that mortality rates for screw traps are typically less than one percent and backpack electrofishing are typically less than three percent. Unintentional mortality rates from seining, dip netting, traps, weirs, and hook and line methods are also limited to no more than three percent.

The quantity of take authorized over the past five years, both lethal and non-lethal, has declined for all four species compared to the prior five years (Table 9). For LCR Chinook salmon, LCR steelhead, and LCR coho salmon percent decreases in authorized take were relatively small. For these same species, actual total numbers of take reported from 2015 through 2019 increased for either all reported take (LCR steelhead), lethal reported take (LCR coho salmon), or both (LCR Chinook salmon) compared to total take reported from 2010 through 2014. Authorized and reported take for CR chum salmon from 2015 through 2019, both lethal and non-lethal, was less than half of the total take authorized and reported during the previous 5-year period. Total lethal take of LCR steelhead reported from 2015 through 2019 also decreased substantially from what was reported from 2010 through 2014.

Overall, research impacts remain minimal due to the low mortality rates authorized under research permits and the fact that research is spread out geographically throughout the Lower Columbia River. Therefore, the overall effect on listed populations has not changed substantially, and we conclude that the risk to the species' persistence because of utilization related to scientific studies has decreased for CR chum salmon and changed little for the LCR species since the last 5-year review (NMFS 2016a).

Table 9. Change in Total Authorized and Total Actual Reported Take of Naturally Produced Juvenile and Adult Lower Columbia River Salmonids between the Prior and Current 5-Year Review Intervals (2010-2014 vs. 2015-2019)

Lower Columbia River ESU/DPS	Authorized Total Take	Authorized Lethal Take	Reported Total Take	Reported Lethal Take
LCR Chinook salmon	- 0.8%	- 8%	+ 12%	+ 16%
LCR steelhead	- 6%	- 9%	+ 8%	- 45%
LCR coho salmon	- 7%	- 12%	- 34%	+ 15%
CR chum salmon	- 51%	- 61%	- 81%	- 72%

Listing Factor B Conclusion

Information available since the last 5-year review indicates that overall, ocean fisheries management and implementation of selective freshwater fisheries continue to reduce harvest impacts on most of the listed LCR Chinook salmon and LCR coho, with the exception of the fall and bright fall-run components of the LCR Chinook salmon ESU where harvest rates are modestly trending upward in recent years (Ford 2022).

We, therefore, conclude that although there have been systematic improvements in fisheries management since the last 5-year review, there remain concerns about both bright fall-run LCR Chinook salmon and LCR coho salmon harvest rate trends. The overall risk to the species' persistence because of overutilization since the 2016 5-year review remains the same.

Scientific research impacts authorized through the West Coast Region have decreased for CR chum salmon and remained relatively stable for LCR Chinook salmon, LCR steelhead, and LCR coho salmon compared to the past five years (NMFS APPS database; https://apps.nmfs.noaa.gov/). Impacts from scientific resource-based mortality are not considered to be major limiting factors for LCR species or CR chum salmon. We conclude that risk from scientific research authorized by the WCR continues to be very low for the LCR Chinook Salmon ESU, LCR Steelhead DPS, and LCR Coho Salmon ESU, and is declining for the CR Chum Salmon ESU.

The risk to species' persistence from overutilization for the:

- LCR Chinook Salmon ESU is increasing due to the modest upward trend in incidental harvest impacts on fall and bright fall-run components of the LCR Chinook Salmon ESU combined with the continuation of very low risk from scientific research impacts.

- LCR Coho Salmon ESU is decreasing due to reduced incidental harvest impacts on lower Columbia River coho combined with the continuation of very low risk from scientific research impacts.

- CR Chum Salmon ESU is decreasing due to reduced incidental harvest impacts and the reduction of authorized scientific research impacts.
- LCR Steelhead DPS is decreasing due to reduced incidental harvest impacts combined with the continuation of very low risk from scientific research impacts.

Listing Factor C: Disease or Predation

Predation

Predation on LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead occurs among birds, other fishes, and marine mammals.

Avian predation

Avian predation in the Lower Columbia River Estuary
A Columbia Basin-wide assessment of avian predation on juvenile salmonids indicates that the most significant impacts to smolt survival occur in the Columbia River estuary (Collis et al. 2009). Although actions to reduce avian predation in the Columbia River basin have been ongoing with implementation of the Federal Columbia River Power System Biological Opinion (NMFS 2010), high levels of avian predation by Caspian terns and double-crested cormorants continue to affect lower Columbia River listed salmonid ESUs and DPS. Further, predation remains a concern due to a general increase in pinniped populations along the West Coast. Non-indigenous fish affect salmon and their ecosystems through many mechanisms.

Overall, avian predation may have decreased slightly since the 2016 5-year review, although those decreases have probably been offset by the movement of cormorants from East Sand Island to the Astoria-Megler Bridge (see below). Impacts of double-crested cormorant predation on subyearling LCR Chinook salmon remain relatively high.

Piscivorous colonial waterbirds, especially terns, cormorants, and gulls, have had a significant impact on the survival of juvenile salmonids in the Columbia River. Caspian terns on Rice Island, an artificial dredged-material disposal island in the estuary, consumed about 5.4 to 14.2 million juveniles per year in 1997 and 1998 (up to 15 percent of all the smolts reaching the estuary; Roby et al. 2017). Efforts to move the tern colony closer to the ocean at East Sand Island, where they would diversify their diet to include marine forage fish, began in 1999. During the next 15 years, smolt consumption was about 59 percent less than when the colony was on Rice Island. The Corps has further reduced smolt consumption by reducing the amount of bare sand available on East Sand Island for nesting from 6 acres to 1 acre. Combined with harassment (kleptoparasitism) by bald eagles and egg and chick predation by gulls, the number of nesting pairs has dropped from more than 10,000 in 2008 to fewer than 5,000 in 2018 and 2019 (Roby et al. 2021).

Hostetter et al. (2021) found that body size affects susceptibility to tern predation. Yearling and subyearling Chinook salmon and yearling coho are smaller than steelhead, so predation rates have been relatively low. Tern predation on Lower Columbia River Chinook salmon declined with the reduction in tern colony size on East Sand Island from an average of 4.1 percent of available PIT-tagged smolts (2000 to 2007) to 2.5 percent more recently (2008 to 2018; Roby et al. 2021). Predation rates for Lower Columbia River coho salmon did not change with the reduction in tern colony size on East Sand Island, averaging 2.6 percent of available PIT-tagged smolts in 2000 to 2007 and 3.1 percent in 2008 to 2018 (difference was not statistically credible; Roby et al. 2021). Yearling steelhead are larger than other species of salmonid (e.g., Chinook, coho, sockeye) and swim higher in the water column, which appears to make them more vulnerable to terns (Collis et al. 2001, Ryan et al. 2001, Antolos et al. 2005, Evans et al. 2012). Predation rates for Lower Columbia River steelhead declined with the reduction in tern colony size on East Sand Island from an average of 15.2 percent of available PIT-tagged smolts (2000 to 2007) to 10.4 percent more recently (2008 to 2018; Roby et al. 2021).

The Corps has also reduced the size of the double-crested cormorant colony on East Sand Island, although efforts to reduce predation rates have not been successful. The pressures of lethal take and non-lethal hazing under the Corps' management plan (USACE 2015), combined with harassment by bald eagles, moved thousands of nesting pairs from the island to the Astoria-Megler Bridge. Because the colony on the bridge is 9 miles further up-river than East Sand Island, these birds are likely to be consuming more juvenile salmonids per capita than when they were foraging further downstream with access to marine forage fish (Lawes et al. 2021). Researchers have not estimated predation rates for birds nesting on the bridge because PIT tags cannot be detected or recovered if they fall into the water.

Based on results from East Sand Island, predation rates by cormorants on Lower Columbia River Chinook salmon have been much higher than on other species of salmonid: 27.5 percent before colony management and even though most of the birds had moved away from the island, 7.3 percent in 2018 (Lawes et al. 2021). Sebring et al. (2013) attributed this to a greater residence time in the estuary and a longer outmigration period for subyearling Chinook salmon compared to lower river steelhead or larger Chinook salmon from the interior Columbia basin. Small subyearling LCR Chinook from tributaries to the lower river rear in nearby floodplain habitats during spring and summer (Kidd et al. 2019) and are available to provide food for cormorants after juveniles from the interior have entered the ocean. Predation rates for East Sand Island cormorants on Lower Columbia River steelhead decreased from 5.4 percent to 0.6 percent when birds moved to the bridge (Lawes et al. 2021) but may have increased for the estuary as a whole. Predation rates for East Sand Island cormorants on Lower Columbia River coho salmon decreased from 15.0 percent to 0.3 percent when birds moved to the bridge (Lawes et al. 2021), but like predation rates for Chinook and steelhead, may have increased for the estuary as a whole.

In contrast to the effects of avian predation on juvenile LCR Chinook, LCR steelhead, and LCR coho, diet studies have indicated that juvenile CR chum salmon are a negligible component of the diet of Caspian terns and double-crested cormorants nesting in the lower Columbia River (Lyons et al. 2014; Collis et al. 2002). This may be because of their small size; juvenile chum salmon migrate through the mainstem as fry. Chum salmon captured in floodplain wetlands are typically less than 60 mm in length (Kidd et al. 2019). Hostetter et al. (2012) and Evans et al. (2019) found that steelhead smaller than 100 mm are of low susceptibility to terns or cormorants.

Avian predation in the mainstem

Juvenile LCR Chinook salmon, steelhead, and coho are not vulnerable to predation by terns nesting in the Interior Columbia plateau or on the Blalock Islands. However, populations of listed salmonids that spawn in tributaries upstream of Bonneville Dam, such as fall- and spring-run Chinook salmon populations that spawn in the White Salmon and Hood rivers, steelhead populations that spawn in the Wind and Hood rivers, and coho that spawn in the White Salmon and Hood rivers, can be affected by predators at Bonneville Dam. The 2008 FCRPS biological opinion first required that the Action Agencies implement avian predation control measures at mainstem dams in the lower Columbia River (NMFS 2008a). Since then, the Corps has used hazing and passive deterrence, including wire arrays across tailraces, water sprinklers at juvenile bypass outfalls, and propane cannons. These measures will continue to be implemented and improved as new techniques become available.

Marine Mammal Predation

The four main marine mammal predators of salmonids in the eastern Pacific Ocean are harbor seals (*Phoca vitulina richardii*), fish-eating killer whales (*Orcinus orca*), California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*).

Recent research over the past five years suggests that predation pressure on ESA-listed salmon and steelhead from seals, sea lions, and killer whales has been increasing in the northeastern Pacific over the past few decades (Chasco et al. 2017). Models developed by Chasco et al. (2017) estimate that consumption of Chinook salmon in the eastern Pacific Ocean by three species of seals and sea lions and fish-eating (Resident) killer whales may have increased from 5 to 31.5 million individual salmon of varying ages since the 1970s, even as fishery harvest of Chinook salmon has declined during the same time period (Marshall et al. 2016; Chasco et al. 2017; Ohlberger 2019). This same modeling suggests that these increasing trends have continued across all regions of the northeastern Pacific over the past five years. The potential predation impacts of specific marine mammal predators of ESA-listed salmonids on the West Coast are discussed individually below.

Pinnipeds

The three main seal and sea lion (pinniped) predators of ESA-listed salmonids in the eastern Pacific Ocean are harbor seals (*Phoca vitulina richardii*), California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*). With the passing of the Marine Mammal Protection Act (MMPA) in 1972, these pinniped stocks along the West Coast of the United States have steadily increased in abundance (Carretta et al. 2019). With their increasing numbers and expanded geographical range marine mammals are consuming more Pacific salmon and steelhead, and some are having an adverse impact on some ESA-listed species (Chasco et al. 2017; Thomas et al. 2017; Marshall et al. 2016).

- California Sea Lion (United States Stock)

  The current population size of California sea lions (CSL) is 257,606 (Carretta et al. 2019). The stock is estimated to be approximately 40 percent above its maximum net productivity level (183,481 animals), and it is, therefore, considered within the range of its optimum sustainable population (OSP) size (Carretta et al. 2019). Estimates of the number of seasonal animals of CSL in the Columbia River basin, based on surveys in the East Mooring Basin, Astoria, Oregon over the past 5 years has ranged from a high of 3,834 animals in 2016 to a low of 805 animals in 2019, with 952 individuals estimated in 2020.

- Steller Sea Lion (Eastern United States Stock)

  The current population size of Steller sea lions (SSL) is 71,562 (52,139 non-pups and 19,423 pups) (Muto et al. 2021).

- Harbor Seals (Oregon and Washington Coast Stock)

  The current population size of the Oregon and Washington Coast stock of harbor seals (HS) is 15,533 (Pearson and Jeffries 2018). This stock's status relative to OSP is unknown.

On a Pacific coast-wide scale, models converting juvenile Chinook salmon into adult equivalents estimated that by 2015 pinnipeds consumed an amount of Chinook salmon six times greater than the combined commercial and recreational catches (Chasco et al. 2017).

At Bonneville Dam, the estimated consumption of adult salmon and steelhead by both CSL and SSL between 2016 and 2019 has ranged from a low 2,201 fish in 2019 to a high of 9,525 fish in 2016 (Tidwell et al. 2020). The percentage of salmon and steelhead runs impacted by both CSL and SSL has ranged from a low of 3.0 percent in 2018 to a high of 5.8 percent in 2016 (Tidwell et al. 2020).

Although CSL have been the primary focus of management efforts at Bonneville Dam and Willamette Falls to date, the presence of SSL has been increasing over time, and now poses a risk to salmon and steelhead recovery. At Bonneville Dam, predation in 2017, 2018, and 2019 on salmon and steelhead by SSL exceeded that of CSL.

Below Bonneville Dam, recent research found that survival of adult spring-summer Chinook salmon through the estuary and lower Columbia River is negatively impacted by higher sea lion abundance for populations with run timing that overlaps with seasonal increases in Steller and California sea lions (Rub et al. 2019; Sorel et al. 2021). Whether increasing sea lion populations are associated with decreased survival of adult salmon and steelhead with later migration timing through the Lower Columbia River and estuary is currently unknown. Some studies have also found that harbor seals can have a significant predation impact on salmon (Thomas et al. 2017) and steelhead (Moore et al. 2021) through the consumption of outmigrating juveniles. Harbor seal predation data specific to the Lower Columbia River is not currently available, so the extent to which predation of outmigrating juveniles in rivers and estuaries is a threat to specific populations is currently unknown.

Management efforts are underway to reduce pinniped predation on Pacific salmon and steelhead in the Lower Columbia River. These efforts are discussed under Listing Factor D (Inadequacy of Regulatory Mechanisms).

Killer Whale Predation
The only whale predators with notable impacts to ESA-listed salmon and steelhead in the northeast Pacific Ocean are fish-eating killer whales (*Orcinus orca*), which include the Northern and Southern Resident populations. Resident killer whales consume a variety of fish species, but salmon are identified as their primary prey, particularly Chinook salmon (Ford and Ellis 2006; Hanson et al. 2010; Ford et al. 2016; Hanson et al. 2021). Southern Resident Killer Whales (SRKWs) occur seasonally throughout the coastal waters off Washington, Oregon, and Vancouver Island and are known to travel as far south as central California and as far north as Southeast Alaska (NMFS 2008c; Hanson et al. 2013). The number of Chinook salmon required to maintain the endangered SRKW population is estimated to be substantial, and large enough to warrant explicit treatment in endangered species recovery (Williams et al. 2011); this population of whales, however, has been declining. The SRKW population has declined from 83 individuals in 2016 to 74 in 2021 (Center for Whale Research, 2021). SRKW are known to feed at and near the mouth of the Columbia, and critical habitat was designated for them along the Oregon and Washington Coasts in 2021 (86 FR 41668), affording greater recognition that salmonids originating in the Columbia River ESUs (primarily Chinook and chum) are also biological elements of their critical habitat.

Predation by Indigenous and Non-indigenous Fish, and Invasive Species

A variety of non-indigenous fishes to the Lower Columbia River recovery domain affect salmon and their ecosystems. A number of studies have concluded that many established non-indigenous species (e.g., smallmouth bass, channel catfish, and American shad) pose a threat to the recovery of ESA-listed Pacific salmon. Threats are not restricted to direct predation; non-indigenous species compete directly and indirectly for resources, significantly altering food webs and trophic structure, and potentially altering evolutionary trajectories (Sanderson et al. 2009; NMFS 2010). Smallmouth bass, channel catfish, and walleye are documented predators. In this section we provide updates on individual indigenous and non-indigenous fish and invasive species, including species occurring in the mainstem Columbia River and its tributaries.

Bass
Largemouth and smallmouth bass are well established throughout the Columbia River basin and known to interact with salmonids. Several studies estimated local predatory impacts of bass on salmonids and suggest a range of potential consumption rates of salmonids by bass (Erhardt and Tiffan 2018; Erhardt et al. 2018; Tiffan et al. 2020). Other studies examine interactions between bass presence and factors such as habitat complexity (Tiffan et al. 2016), potential for competition (Rubenson et al. 2020; Lawrence et al. 2012), and thermal conditions. In particular, thermal conditions may influence current and future degree of spatial overlap, which ultimately drives spatial overlap and the potential for species interactions, including predation (Hawkins et al 2020; Rubenson and Olden 2016; Rubenson and Olden 2020).

Walleye
Walleye are a well-established and documented predator to salmonids throughout the Columbia Mainstem. No new studies documenting walleye predation impacts have come out in the last 5

years.

Channel catfish

Channel catfish are a well-established and documented predator to salmonids throughout the Columbia Mainstem. No new studies documenting channel catfish predation impacts have come out in the last 5 years.

Northern Pike

Northern Pike were introduced illegally and established a population in eastern Washington, including the Pend Oreille River, Spokane River, and Lake Roosevelt. They have not yet been found downstream of mainstem Columbia River dams, but there is a high level of concern about the potential spread of this species (https://invasivespecies.wa.gov/priorityspecies/northern-pike-2/).

Management Actions

On January 1, 2016, WDFW and ODFW lifted limits on smallmouth bass, channel catfish, and walleye in the Columbia River in an effort to reduce predator populations. See http://wdfw.wa.gov/fishing/regulations/ that list the lack of a catch limit on these species.

Northern Pikeminnow

Some indigenous fish species are also recognized as significant predators of ESA-listed salmonids in the lower Columbia River basin, such as the Northern pikeminnow. The native Northern pikeminnow (*Ptychocheilus oregonensis*) is a significant predator of juvenile salmonids in the Columbia and Snake rivers followed by non-native smallmouth bass and walleye (reviewed in Friesen and Ward 1999; ISAB 2011; ISAB 2015). The construction of dams and dredging of waterways in the Columbia River basin has created reservoirs and islands from dredged spoils that have facilitated population explosions of the native Northern pikeminnow (Waples et al. 2008). In 1990, a sport fishing reward program was implemented to reduce the numbers of Northern pikeminnow in the Columbia River basin to reduce predation upon juvenile salmon and steelhead (NMFS 2010). Further, NMFS' 2008 FCRPS Opinion recommended the Northern Pikeminnow Management Program (RPA Action 43) to continue the sport-reward fishery while evaluating its effectiveness (NMFS 2008b) which was further expanded in the 2014 FCRPS Supplemental Opinion (NMFS 2014).

Before the start of the Northern Pikeminnow Management Plan in 1990, this species was estimated to eat about 8 percent of the 200 million juvenile salmonids that migrated downstream in the Columbia River each year. Williams et al. (2017) estimated a median reduction in Northern pikeminnow predation rates on juvenile salmonids of 30 percent compared to before the start of the program. In addition to the Sport Reward Fishery, the Action Agencies conduct a Dam Angling Program to remove large pikeminnow from the tailraces of The Dalles and John Day Dams. Angling crews removed an average of 5,728 northern pikeminnow from these two projects per year during 2015 to 2019 (Williams et al. 2016; Williams et al. 2017; Williams et al. 2018; Winther et al. 2019).

Disease

Disease rates over the past five years are believed to be consistent with the previous review period. In the Columbia River estuary, the parasite *Ceratonova shasta* was detected in 9.6 percent and 12 percent of juvenile Chinook salmon in 1983 and 2001, respectively, and a strain of infectious haematopoietic necrosis virus (IHNV) was detected on along the Pacific Coast that originated in the Columbia River was reported in 2011 (Kurath 2012). Recent studies also suggest that a freshwater parasite, *Ceratonova shasta*, may be limiting the survival of juvenile chum salmon (WDFW and ODFW 2019). The prevalence of IHNV across the CRB and coastal watersheds of Washington and Oregon is currently reported as 29.1 percent in steelhead trout, 21.9 percent in sockeye salmon, and 20.1 percent in Chinook salmon (Breyta et al. 2017; Hernandez et al. 2021).

There was concern that this strain of IHNV would be more virulent and increase the spread of the infection, but these concerns have not been borne out as IHNV reports in the basin have declined in the past few years. These fluctuations in the disease rates are considered normal but current high water temperatures and low water flows, associated with climate change effects, could suppress salmonid immune systems and lead to increased disease rates.

Listing Factor C Conclusion

The prevalence of disease has not resulted in notable levels of injury or mortality within the last 5-year period, but it is reasonable to assume that warming trends have increased the risk of predation and disease (*C. shasta*) to ESU or DPS viability (Myers, NWFSC, personal communication, December 20, 2021). The information available since the last 5-year review clearly indicates that predation by pinnipeds on Pacific salmon and steelhead continues to pose an adverse impact on the recovery of these ESA-listed fish species. Therefore, while there are management efforts underway to reduce pinniped predation on Pacific salmon and steelhead in select areas of the Columbia River basin, these management efforts alone may be insufficient to reduce the severity pinniped predation poses to the recovery of Pacific salmon and steelhead in the Columbia River basin.

Evidence from recent studies on other Columbia Basin salmon species suggests that pinniped predation could be an important factor impacting the Lower Columbia River ESUs and the DPS; however, we do not have information that would allow us to quantify the species-specific impacts at this time. Recent sea lion removal efforts in the Columbia Basin may have reduced pinniped predation pressure on lower Columbia River species, although the effects of this program to the Lower Columbia River ESUs and the DPS are also unknown outside the areas immediately below Bonneville Dam and Willamette Falls. Avian predation also appears to continue to negatively impact juvenile salmon and steelhead survival in the lower Columbia River, and recent changes to avian predation management do not appear to have altered the overall impacts to these species. We, therefore, conclude that the risk to the species' persistence due to predation has not changed since the last 5-year review.

Disease rates have continued to fluctuate within the range observed in past review periods. We, therefore, conclude that the risk to the species' persistence due to disease has increased slightly since the last 5-year review.

Recommended Future Actions

- Pacific salmon and steelhead recovery partners are encouraged to develop and implement a long-term management strategy to reduce pinniped predation on Pacific salmon and steelhead in the Columbia River basin by removing, reducing, and-or minimizing the use of manmade haul outs used by pinnipeds in select areas (e.g., river mouths/migratory pinch points).
- Pacific salmon and steelhead recovery partners are encouraged to expand, develop, and implement monitoring efforts in the Columbia River basin, to identify pinniped predation interactions in select areas (e.g., river mouths/migratory pinch points) and quantitatively assess predation impacts by pinnipeds on Pacific salmon and steelhead stocks.

Listing Factor D: Inadequacy of Regulatory Mechanisms

Various federal, state, county, and tribal regulatory mechanisms are in place to reduce habitat loss and degradation caused by human use and development and harvest impacts. For this 5-year review, we focus our analysis on regulatory mechanisms for **Habitat** and for **Harvest** that have either improved for LCR steelhead, LCR Chinook salmon, CR chum, and LCR coho, or that are still causing the most concern in terms of providing adequate protection for these LCR species.

Habitat

Habitat concerns are described throughout Listing Factor A as having either a system-wide influence, or more localized influence, on the populations and MPGs that comprise the four species. The habitat conditions across all habitat components (tributaries, mainstems, estuary, and marine) necessary to recover listed LCR steelhead, LCR Chinook salmon, CR chum, and LCR coho are influenced by a wide array of federal, state, and local regulatory mechanisms. The influence of regulatory mechanisms on listed salmonids and their habitat resources is largely based on the underlying ownership of the land and water resources as federal, state, or private holdings.

One factor affecting habitat conditions across all land or water ownerships is climate change, the effects of which are discussed under Section 2.3.2 (Listing Factor E: Other natural or manmade factors affecting its continued existence). We reviewed summaries of national and international regulations and agreements governing greenhouse gas emissions, which indicate that while the number and efficacy of such mechanisms have increased in recent years, there has not yet been a substantial deviation in global emissions from the past trend. Upscaling and acceleration of far-reaching, multilevel, and cross-sectoral climate mitigation will be needed to reduce future climate-related risks (IPCC 2018). These findings suggest that current regulatory mechanisms, both in the U.S. and internationally, are not adequate to address the rate at which climate change negatively impacts habitat conditions for many ESA-listed salmon and steelhead. This is particularly true for Gorge MPG species, which are experiencing flashier flood regimes due, in part, to climate change and where flood conditions are exacerbated by historical land use practices such as splash dams for logging.

According to the NMFS Geographic Information System (GIS) database, roughly 39 percent of land in the Lower Columbia River region is in federal ownership, with approximately 47 percent of the Washington headwaters of the lower basin in the Gifford Pinchot National Forest. Federal land managers have taken numerous measures to protect and restore habitat throughout the range of the LCR salmon ESUs and steelhead DPS. Since the last 5-year review, habitat improvements and restoration activities have continued to occur on federal lands through the implementation of the Northwest Forest Plan (NWFP) and under the Aquatic Habitat Restoration Activities Biological Opinion (ARBO) (NMFS 2013b) and other management efforts. Web-based USGS data to evaluate habitat trends within the Gifford Pinchot have been made unavailable. Accordingly, uncertainty remains over the future conservation of lower Columbia River salmon and steelhead on federal lands. The level of protection afforded to the lower Columbia River ESUs and DPS and their habitat will be determined on federal lands by land management plans currently under development by the USFS and the U.S. Bureau of Land Management (BLM).

Regulatory Mechanisms Resulting in Adequate or Improved Protection

New information available since the previous 2016 5-Year Review indicates that the adequacy of some habitat regulatory mechanisms has improved and has increased protection of LCR steelhead, LCR Chinook salmon, CR chum, and LCR coho. These include both federal and state water management regulatory mechanisms:

1. Wildfire Management and Suppression (consistent with Organic Acts for National Forest Service and National Park Service)

As a general matter, extensive wildfires (http://gacc.nifc.gov/nwcc/information/firemap.aspx) have affected habitat quality in burned areas, which are likely to incorporate areas of or near salmonid habitat, with a range of potential effects. Wildfires are naturally occurring, but the frequency and intensity of fires has increased as a result of fire suppression which causes development of unnatural tree species mixes and an unnaturally high density of trees which then results in higher than normal mortality of trees due to insect infestations and disease (Agee 1996). Fire frequency and area burned appears to be significantly increasing as a consequence of climate change. Fire management and response plans have been developed or are being developed by various federal land management agencies, including the National Park Service and the USFS. Such plans can benefit riparian and stream habitat conditions range-wide for LCR species.

2. The Endangered Species Act Section 7 Biological Opinions

The Columbia River System **-** Since 2008, under biological opinions for the Columbia River System (NMFS 2008a; NMFS 2014; NMFS 2019d; NMFS 2020b), the U.S. Army Corps of Engineers, U.S. Bureau of Reclamation, and Bonneville Power Administration (collectively referred to as the CRS Agencies) operated the Columbia River System (formerly referred to as the Federal Columbia River Power System) in accordance with a Reasonable and Prudent Alternative (RPA) that included both operational and non-operational measures expected to minimize project effects and improve the survival of migrating ESA-listed salmon and steelhead (as well eulachon and green sturgeon) and the function of their critical habitat in the Columbia River.

Beginning in 2019, the CRS Agencies proposed to continue many operational and non-operational measures from the previous RPA but also included mainstem dam operations consistent with a 2019 to 2021 Spill Operation Agreement. The NMFS 2019 biological opinion evaluated the effects of that interim proposed action (NMFS 2019d). The NMFS 2020 biological opinion evaluated the effects of the CRS Agencies longer-term proposed action, which included increased spill operations intended to improve passage conditions for juvenile salmon, and habitat mitigation intended to improve habitat conditions in the tributaries, as well as in the lower Columbia River estuary. The most important measures for species in the Lower Columbia River included:

- Improved Floodplain and Estuary Habitat. The CRS Agencies are implementing an estuary habitat improvement program (the Columbia Estuary Ecosystem Restoration Program, CEERP), reconnecting the historic floodplain below Bonneville to the mainstem Columbia River. From 2007 through 2019, the CRS Agencies implemented 64 projects, including dike and levee breaching or lowering, tide-gate removal, and tide-gate upgrades that reconnected over 6,100 acres of historic tidal floodplain habitat to the mainstem and another 2,000 acres of floodplain lakes (Karnezis, personal communication, December 19, 2019; BPA et al. 2020). In addition to this extensive reconnection effort, about 2,500 acres of currently functioning floodplain habitat have been acquired for conservation.

- Requirements to limit winter drafts to flood risk management upper rule curves to minimize operational impacts (reductions) to spring flows.

- Improvements in structures and operations at Bonneville Dam to improve passage conditions for juvenile and adult salmon and steelhead from populations upstream of Bonneville Dam and better protect Columbia River chum spawning downstream of the project.

- Avian and fish predator management programs in Bonneville reservoir and the lower Columbia River (e.g., Caspian terns, double crested cormorants, and northern pikeminnow).

- Tributary habitat restoration projects for Columbia River chum (primarily in Hamilton Creek) downstream of Bonneville Dam.

These measures help address issues of mainstem channel simplification and habitat complexity, and some predation concerns (See Listing Factor C for more information on predation).

<u>EPA's Columbia Cold Water Refuges Plan</u> - EPA worked with the States of Oregon and Washington, NMFS, tribes, and others to develop this plan, released in February 2021. This plan is a scientific document with recommendations for actions. EPA issued this plan in response to consultation under Section 7 of the Endangered Species Act (NMFS 2015b), associated with its approval of Oregon's temperature standards for the Columbia River. This plan also serves as a reference for EPA's Columbia and Snake Rivers Temperature Total Maximum Daily Load (TMDL). The Columbia Cold Water Refuges (CWR) Plan assesses the amount of CWR needed to attain Oregon's Clean Water Act CWR narrative water quality standard, identifies actions to

protect and restore CWR, and recommends future CWR studies. EPA recommends restoration of other tributaries to create more cold water refuge in light of predicted continued warming of the lower Columbia River. This plan should help address the water quality implications of climate change.

3. Federal Clean Water Act
Some authority for clean water regulation is retained by EPA and the Corps of Engineers, and some authority is delegated to the states.

EPA Toxic Clean-up Grants - In December 2016, the United States Congress (Congress) amended the Clean Water Act by adding Section 123, which requires EPA and OMB to take actions related to restoration efforts in the Columbia River basin. In 2018, the U.S. Government Accountability Office (GAO) presented a report - *Columbia River Basin, Additional Federal Actions Would Benefit Restoration Efforts* (GAO 2018). The report indicated that, since 2016, the EPA had not taken steps to establish the Columbia River Basin Restoration Program, as required by the Clean Water Act Section 123. EPA subsequently developed a grants program in 2019, and in September of 2020 announced the award of $2 million in 14 grants to tribal, state and local governments, non-profits, and community groups throughout the Columbia River basin (EPA 2020). These grants should help reduce chemical contamination in the Columbia River.

4. Federal Power Act - Tacoma Power's Cowlitz River Hydroelectric Project
Tacoma Power finished work on the Cowlitz Falls North Shore Collector (CFNSC), enabling downstream passage at Cowlitz Falls Dam in 2017. Testing for the 2020 season was limited to PIT tags which make it difficult to determine if and where fish may be rejecting the facility. PIT tag and Acoustic Tag testing in 2019 determined that the FPS estimates for steelhead, Coho salmon, and Chinook salmon were 83.0 percent, 93.4 percent, and 77.8 percent, respectively. A number of steelhead were detected entering the CFNSC but ultimately rejected the facility. Additional facility improvements are required until a minimum 75 percent FPS is achieved with best available technology.

The collector helps address passage limitations/spatial structure in the Cascade MPG.

5. State of Washington's Fish Passage Barrier Removal Board (Revised Code of Washington (RCW) 77.95.160)
In 2015, the Washington State legislature created the Fish Passage Barrier Removal Board to establish a new statewide strategy for fish barrier removal and administering grant funding available for that purpose. The legislation established several key objectives for the new strategy including:

- Coordinating with all relevant state agencies and local governments to maximize state investments in removing fish barriers.
- Realizing economies of scale by bundling projects whenever possible.
- Streamlining the permitting process whenever possible without compromising public safety and accountability.

Table 10. Annual Fish Passage by Species.

Year	Steelhead	Coho	Chinook
2017 (Shakedown Season)	57.4%	51.6%	50.7%
2018	74.8%	83.1%	69.5%
2019	83.0%	93.4%	77.8%

Information taken from Cowlitz Falls North Shore Collector Downstream Fish Evaluation 2019 Annual Report by Four Peaks Environmental Science and Data Solutions and Anchor QEA, LLC. Date March 2020.

Chaired by WDFW, the board includes representatives of the Washington State Department of Transportation, WDNR, Tribes, city and county governments, and the Governor's Salmon Recovery Office. In developing the statewide strategy, the board has been working closely with salmon recovery organizations to approve statewide guidelines.

The program helps increase tributary access/spatial structure across all MPGs.

6. Oregon Fish Passage Guidance (ORS 509.585)

Oregon Department of Fish and Wildlife (ODFW) has developed new fish passage policy guidance in July 2021, and project review procedures for instream habitat restoration projects designed to specifically mimic instream natural habitat features created by beavers and beaver dams. The primary goal of this new policy guidance bulletin is to streamline and expedite the state's fish passage review and approval procedures for instream habitat restoration projects designed and implemented to specifically mimic natural habitat features created by beaver and beaver dams. This guidance benefits habitat complexity for LCR species in Oregon streams.

7. Oregon's Mining Regulations (ORS 517 *et seq*)

Effective in 2018, Oregon legislation placed restriction on motorized in-stream placer mining https://www.oregon.gov/dsl/WW/Pages/Mining.aspx. In order to protect indigenous anadromous salmonids and habitat essential to the recovery and conservation of Pacific lamprey, motorized in-stream placer mining is not permitted to occur below the ordinary high water line in any river in Oregon containing essential indigenous anadromous salmonid habitat. Oregon Department of Environmental Quality has an online interactive map that shows areas where motorized in-stream placer mining is prohibited. This restriction is beneficial to spawning and rearing condition throughout Oregon streams.

http://geo.maps.arcgis.com/apps/webappviewer/index.html?id=1fedde6ecbff46feb7c41524f21d42d7

8. Oregon Forest Practices Regulations (OAR 629)

Oregon Forest Practices Act stream rules were amended in 2017 to increase buffer widths around many salmon, steelhead, and bull trout streams by 10 feet and retain more trees on private forestlands (Oregon Administrative Rule 629-645-0000). This revision might incrementally improve stream conditions large wood input, temperature, and prey base in many Oregon streams. Effective July 1, 2017, these rules may have improved water quality by increasing shade and reducing sedimentation. Some of the highest quality coho salmon rearing habitat is on private forestlands, making these rule changes positive for salmon survival and recovery.

However, we remain concerned that rules regarding road maintenance and density on private forest lands are still not adequate to address their ongoing impacts on water quality. While buffer widths were recently increased with the regulatory revision it is also not yet known the extent to which they will protect water quality for Oregon populations of each MPG.

(https://www.oregon.gov/ODF/Documents/WorkingForests/FPAFactSheet.pdf)

Oregon Department of Forestry Reports are produced by separate districts. (https://www.oregon.gov/odf/pages/reports.aspx)

Regulatory Mechanisms Resulting in Inadequate or Decreased Protection

Although some habitat regulatory mechanisms have improved, we remain concerned about the adequacy of existing habitat regulatory mechanisms with regard to water quality, Columbia River mainstem conditions, habitat complexity, forest cover, and passage at high head dams particularly for Cascade MPG populations.

Federal Land and Water Management

1. BLM Revised Resource Management Plan

NOAA completed ESA consultation (NMFS 2016b) for the BLM Resource Management Plan (RMP) for 2.6 million acres of Western Oregon. The conservation strategy developed for the BLM RMP included very conservative Hydrology and Riparian Reserve management direction for protection of water quality and fish. Such action included 120' no-touch inner buffers on all perennial streams, and additional high protections for intermittent streams based on a key watershed strategy. However, a District Court overturned the new BLM RMP when the Swanson Group and the Association of O&C Counties sued the BLM (Civil No 16-01599-RJL, Civil No. 15-01419-RJL and Civil No. 01602-RJL. Further judicial rulings are still pending.

The USFS continues to manage its lands under the Northwest Forest Plan and the BLM continues to manage under its new BLM RMP. We continue to rely on both federal land management agencies to provide for the habitat needs of all four Lower Columbia Species in the Cascade MPG, and LCR Chinook, CR chum, and LCR coho salmon in the Coast MPG. Sufficiency of tall canopy tree cover in riparian areas is a concern for Coast and Cascade MPGs.

2. Federal Power Act

Federal Energy Regulatory Commission licensing provisions govern several facilities in Lower Columbia River tributaries. Operational changes implemented or revised since the 2016 5-year review include:

Lewis River (for PacifiCorp's Lewis River Hydroelectric Project)

The North Fork (NF) Lewis River has four hydropower projects operated by PacifiCorp and the Cowlitz County PUD No. 1, all licensed by FERC as the Lewis River Hydro Project. A settlement agreement in 2004 among 22 parties required the addition of upstream and downstream fish passage at each of the three PacifiCorp-owned dams (six fish passage structures total), Swift No.1, Yale, and Merwin, by 2021. An upstream collector was installed in 2012 in the Merwin Dam to collect adults and move them via truck to habitats above Swift Reservoir, and a downstream floating surface collector was installed in 2013 within Swift Reservoir to capture outmigrating salmonids to be trucked below Merwin Dam to the NF Lewis River. To date these are the only fish passage structures built and operating. While additional fish passage was required by 2021, these passage components are affected by a multiple year delay. Obstruction to passage is identified as the most significant limitation in spatial structure for the Cascade MPG.

3. Federal Clean Water Act

The Federal Clean Water Act of 1973 addresses the development and implementation of water quality standards, the development of Total Maximum Daily Loads (TMDLs)[13] filling of wetlands, point source permitting, the regulation of stormwater, and other provisions related to protection of U.S. waters. Some authority for clean water regulation is retained by EPA and the Corps of Engineers, and some authority is delegated to the states.

Retained Authority - Section 404 of the Clean Water Act (CWA) requires the Corps of Engineers to regulate the discharge of dredged or fill material into waters of the United States, including wetlands, through permitting. Activities in waters of the United States regulated under this program include fill for development, water resource projects (such as dams and levees), infrastructure development (such as highways and airports) and mining projects. Section 404 requires a permit before dredged or fill material may be discharged into waters of the United States, unless the activity is exempt from Section 404 regulation (e.g., certain farming and forestry activities). Permits may be individual, or general permits for a class of activities, such as "nationwide permits."

In 2017 the Corps re-issued and expanded the Nationwide Permit Program (NWP) program to 52 permits. On September 15, 2020, the Corps issued a public notice to reissue and modify the nationwide permits (85 FR 57298, pages 57298-57395). We remain concerned that the program cannot authentically demonstrate that adverse cumulative effects on the environment are avoided, or that jeopardy and adverse modification will not result, because, among other reasons, general condition 10 requires compliance with National Flood Insurance Program (NFIP) minimum criteria which have been found to jeopardize species.

When these permits are issued at sites in the Lower Columbia River or tributaries to the Lower Columbia River, they create temporary and permanent reduction in habitat values. The Corps uses its CWA Section 404 authority multiple times per year to permit in and overwater actions in the Lower Columbia River and its tributaries, impairing the habitat of all four LCR salmonids both temporarily and permanently.

Delegated Authority - The Clean Water Act is administered in the States of Oregon and Washington with oversight by the U. S. Environmental Protection Agency (EPA). State water quality standards are set to protect beneficial uses, which include several categories of salmonid use. Together the state and federal clean water acts regulate the level of pollution within streams and rivers in Oregon and Washington.

[13] A TMDL is a pollution budget and includes a calculation of the maximum amount of a pollutant that can occur in a waterbody and allocates the necessary reductions to one or more pollutant sources. A TMDL serves as a planning tool and potential starting point for restoration or protection activities with the ultimate goal of attaining or maintaining water quality standards.

Each state has a water quality section 401 certification program that reviews projects that will discharge dredged or fill materials into waters of the United States and issues certifications that the proposed action meets State water quality standards and other aquatic protection regulations, if appropriate. Each state also issues National Pollution Discharge Elimination System (NPDES) permits under section 402 for discharges from industrial point sources, waste-water treatment plants, construction sites, and municipal stormwater conveyances to allow for the discharge of constituents into the lower Columbia River, with established parameters for the allowance of mixing zones if the discharged constituent(s) do(es) not meet existing water quality standards at the 'end of the pipe.' TMDLs are prepared to develop actions to reduce concentrations of specific contaminants or natural constituents recognized within a waterbody[14] that fail to meet water quality standards in repeated testing.

In December 2018, the EPA issued final approval of Oregon's 2012 Integrated Report and 303(d) list. EPA added 285 water bodies to the list, removed 56 water bodies from the list, and reclassified 714 stream segments affected by ongoing litigation over temperature water quality standards.

The Oregon Department of Environmental Quality submitted its 2018/2020 Integrated Report in April 2020, to the Environmental Protection Agency. The current EPA assessment characterizes assessed rivers and streams in Oregon that support fish and aquatic life. In Oregon, there are roughly 19,000 miles of good habitat and roughly 113,000 miles of impaired habitat. https://mywaterway.epa.gov/state/OR/water-quality-overview. https://www.oregon.gov/deq/wq/pages/2018-integrated-report.aspx

Washington State relies on use-based (e.g., aquatic life use) Surface Water Quality Standards, found in Washington Administrative Code (WAC) 173-201A. The EPA approved the Washington State's updated Water Quality Assessment 305(b) report and 303(d) list in 2012. It has not been updated since that date. (http://www.ecy.wa.gov/programs/Wq/303d/index.html).

In December 2019 the Ninth Circuit Court of Appeals issued an opinion that the EPA must identify a temperature TMDL for the Columbia River as neither the State of Washington nor Oregon has provided a temperature TMDL. In January 2021 EPA released its Columbia River Cold Water Refuges Plan. On August 30, 2021, EPA reissued a temperature TMDL for Columbia and Lower Snake Rivers to comply with the Court Order.

The Clean Water Act has not been sufficient to prevent pollution of the Lower Columbia River. Toxic contamination through the production, use, and disposal of numerous chemicals from multiple sources including industrial, agricultural, medical and pharmaceutical, and common household uses enter the Columbia River in wastewater treatment plant effluent, stormwater runoff, and nonpoint source pollution remains a growing concern (Morace 2012; Nilsen and Morace 2014).

[14] Under section 303(d) of the Clean Water Act, states, territories and authorized tribes (included in the term State here) are required to submit lists of impaired waters. These are waters that are too polluted or otherwise degraded to meet water quality standards. A TMDL is only issued if a contaminant is on the 303(d) list for the specific water body.

4. Section 10 Rivers and Harbors Act

Often executed concurrently with section 404 of the Clean Water Act (discussed above) the Rivers and Harbors Act of 1899 (33 U.S.C. 403) prohibits the unauthorized obstruction or alteration of any navigable water of the United States. This section authorizes the Corps of Engineers to permit construction of any structure in or over any navigable water of the United States, or any other work affecting the course, location, condition, or physical capacity of such waters. It includes, without limitation, any wharf, dolphin, weir, boom breakwater, jetty, groin, bank protection (e.g. riprap, revetment, bulkhead), mooring structures such as pilings, aerial or subaqueous power transmission lines, intake or outfall pipes, permanently moored floating vessel, tunnel, artificial canal, boat ramp, aids to navigation, and any other permanent, or semi-permanent obstacle or obstruction.

These structures generally have a design life of 30-75 years and constitute long term alteration to rearing and migration habitat values in LCR and its tributaries. The purpose of these structures is often to support recreational or commercial vessels and navigation. As described in Listing Factor A, vessel traffic also impairs habitat conditions for the LCR species via water quality impacts and increasing the likelihood of wake stranding. Wake stranding is a concern with few regulatory mechanisms to address it.

5. National Flood Insurance Program

The National Flood Insurance Program (NFIP) is a federal benefit program that extends access to federal monies or other benefits, such as flood disaster funds and subsidized flood insurance, in exchange for communities adopting local land use and development criteria consistent with federally established minimum standards. Under this program, development within floodplains continues to be a concern because it facilitates development in floodplains without mitigation for impacts on natural habitat values.

All West Coast salmon species, including 27 of the 28 species listed under the ESA, are negatively affected by an overall loss of floodplain habitat connectivity and complex channel habitat. The reduction and degradation of habitat has progressed over decades as flood control and wetland filling occurred to support agriculture, silviculture, or conversion of natural floodplains to urbanizing uses (e.g., residential and commercial development). Loss of habitat through conversion was identified among the factors for decline for most ESA-listed salmonids. "NMFS believes altering and hardening stream banks, removing riparian vegetation, constricting channels and floodplains, and regulating flows are primary causes of anadromous fish declines (65 FR 42450 July 10, 2000)"; "Activities affecting this habitat include…wetland and floodplain alteration; (64 FR 50414 Sept. 16, 1999)."

Development proceeding in compliance with NFIP minimum standards ultimately results in impacts to floodplain connectivity, flood storage/inundation, hydrology, and to habitat forming processes. Development consequences of levees, stream bank armoring, stream channel alteration projects, and floodplain fill, combine to prevent streams from functioning properly and result in degraded habitat. Most communities (counties, towns, cities) in Washington and Oregon are NFIP participating communities, applying the NFIP minimum criteria. For this reason, it is important to note that, where it has been analyzed for effects on salmonids, floodplain development that occurs consistent with the NFIP's minimum standards has been found to jeopardize 18 listed species of salmon and steelhead (Chinook salmon, steelhead, chum salmon, coho salmon, sockeye salmon) (NMFS 2008d; NMFS 2016c). The Reasonable and Prudent Alternative provided in NMFS 2016c (Columbia Basin species, Oregon Coast coho salmon, Southern Oregon/Northern California Coast coho salmon) has not yet been implemented.

Non-Federal Land/Water Management

1. Oregon State Regulatory Mechanisms Affecting Beaver Management

Beaver removal in Oregon over the last 250 years has resulted in profound changes to stream and wetland conditions. Some of the characteristics most pertinent to salmonids include channel simplification, loss of wetted area, increased water velocity, decreased invertebrate production, and decreased floodplain connection (Naiman et al. 1988). While beaver populations have rebounded the last few decades (Pollock et al. 2017), the effects of their removal persist throughout Oregon. Currently, it is illegal for anyone to move beaver in Oregon without a permit from ODFW, (ORS 497.308) and ODFW has published beaver relocation guidelines relative to beavers and their dams on private property at https://www.dfw.state.or.us/wildlife/living_with/docs/beaver.pdf

However, on private land in Oregon, beaver are classified as a predatory species (ORS 610.002), and landowners may lethally remove beaver on sight, without a permit from ODFW or requirement to report such removal. ODFW also manages a trapping season for beavers. On public land, beaver are classified as a protected furbearer (ORS 496.004 and OAR 635-050-0050). ODFW requires a permit to take protected furbearers. For beaver, this permit includes the designated trapping season, but does not limit the numbers of beaver taken.

Beaver dams and ponds create habitat complexity that serves all LCR MPGs, particularly spring Chinook, coho, and steelhead. All current protective efforts in Oregon are voluntary, and there is low certainty they will be fully implemented. Beaver removal and beaver dam removal under Oregon law impair natural establishment of complex instream habitat conditions that would promote additional rearing habitat for all salmonid species.

2. Washington Forest Practices Regulations

NMFS approved the State’s Forest Practice Rules as ESA-compliant by signing the Forest Practice Rules Habitat Conservation Plan (HCP) in 2006. Commercial forestlands are managed to assist salmon recovery, including state-owned forestlands managed per another HCP approved in 1999. In 2015, stream-typing protocols in Washington State were specifically noted by NMFS and the USFWS to be inaccurate, and thus under-identify streams as fish habitat, such that the protective value of the regulations is not carried forward adequately across the state. In 2017, the Forest Practices Board approved a fish habitat assessment method (FHAM) as the field protocol for delineating the upper extent of fish habitat within a stream segment. Part of the application of FHAM includes the identification of field measurable geomorphic features—called potential habitat breaks—which with reasonable certainty impede upstream fish movement indicating the end of fish habitat. However, stream typing protocols and corollary stream protections remain a point of significant concern. We have data of warmer than expected water under the typing method, but the adaptive management process has yet to respond. The delay in developing a model-based stream typing tool has caused corollary delays that are now a point of discussion between the

Federal Caucus and the State of Washington. The modifications in timber practices have largely created a passive restoration strategy for the riparian corridors of streams and rivers within forest land areas.

3. Streamflow Restoration (90.994 RCW)

In January 2018, the Washington State Legislature passed the Streamflow Restoration law that helps restore stream flows to levels necessary to support robust, healthy, and sustainable salmon populations while providing water for homes in rural Washington. The State law requires that enough water is kept in streams and rivers to protect and preserve instream resources and values such as fish, wildlife, recreation, aesthetics, water quality, and navigation.

One of the most effective tools for protecting streams is to set instream flows, which are flow levels adopted into rule. Instream flow rules cover nearly half of the state's watersheds and the Columbia River (see Figure 5). Many uses are exempt from permitting requirements, however, including livestock watering, non-commercial lawn or garden watering less than half an acre, domestic uses and small industrial uses (under 5,000 gallons/day). Collectively, the unregulated uses cause a significant cumulative effect on stream recharge, reducing cool water and base flows necessary for summer and early fall survival of listed fish. Some uses of water, particularly during low flow, can have direct impacts to fish, by preventing upstream passage and even survival if water temperatures are too high.

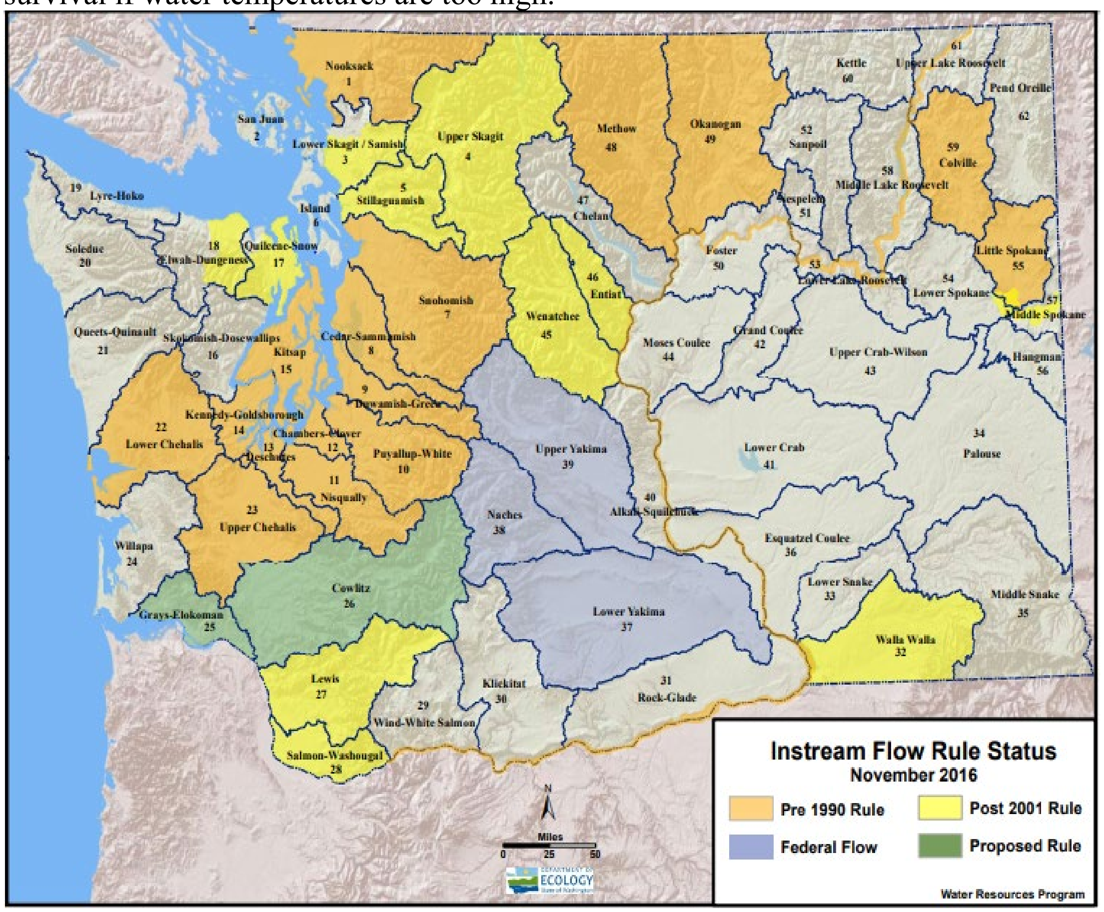

Figure 5. WRIAs Instream Flow Rule status, 2016.

In Washington, out-of-stream uses, especially irrigation, exacerbate seasonally low flows, leading to passage and temperature problems, and the loss of habitat. Instream flow rules have not been completed for WRIA 26, where many Cascade MPG populations are located.

Harvest

Pacific Salmon Treaty

Ocean fisheries in Southeast Alaska, British Columbia, and off the coasts of Washington and most of Oregon are managed under the Pacific Salmon Treaty (PST), which was initially ratified by the United States and Canada in 1985. The PST is implemented by the Pacific Salmon Commission, which negotiates, facilitates, and monitors the implementation of fishing regimes developed under the treaty. In the United States south of the Canadian border, the Pacific Fishery Management Council (PFMC) is responsible for regulating regimes agreed to by the Pacific Salmon Commission, while the North Pacific Fishery Management Council (NPFMC) has jurisdiction for ocean fisheries off Alaska.

Pacific Fishery Management Council

Since 1977, salmon fisheries in the exclusive economic zone (EEZ) (three to 200 nautical miles offshore) off Washington, Oregon, and California have been managed under salmon Fishery Management Plans (FMPs) of the PFMC. While all species of salmon fall under the jurisdiction of the current plan (Pacific Fisheries Management Council 2021), the FMP currently contains fishery management objectives only for Chinook salmon, coho, pink (odd-numbered years only), and any salmon species listed under the ESA that is measurably impacted by PFMC fisheries.

The effects of the salmon fisheries on ESA listed salmonids is limited by fishery management measures implemented under the Magnuson-Stevens Fishery Conservation and Management Act, as well as terms and conditions and reasonable and prudent alternatives developed by NMFS through consultations under ESA section 7. These measures take a variety of forms including FMP conservation objectives, limits on the time and area during which fisheries may be open, ceilings on fishery impact rates, and reductions from base period impact rates. NMFS annually issues a guidance letter to the PFMC reflecting the most current information for developing management objectives (e.g., Thom 2020).

North of Falcon

Ocean fisheries between Cape Falcon (on the north Oregon coast) and the Canadian border are coordinated with fisheries in the Columbia River, Puget Sound, and coastal rivers through the North of Falcon (NOF) process. This process was established by the states and the Northwest Indian Fisheries Commission member tribes; it occurs largely coincident with the PFMC process. In the NOF process, co-managers develop pre-season fishing plans that are coordinated between ocean and in-river fisheries to ensure that conservation and various allocation objectives are met. Allocation objectives include treaty/non-treaty tribal allocations and allocations between various non-treaty user groups, such as commercial and recreational fisheries.

Columbia River Harvest Management: *U.S. v. Oregon*

Harvest impacts on LCR salmon and steelhead in mainstem Columbia River fisheries in mainstem commercial, mainstem recreational, and mainstem treaty fisheries continue to be managed under the 2018-2027 *U.S. v. Oregon* Management Agreement (NMFS 2018b). The parties to the agreement are the United States, the states of Oregon, Washington, and Idaho, and four Columbia River Treaty Tribes: Warm Springs, Yakama, Nez Perce, and Umatilla. The agreement sets harvest rate limits on fisheries impacting lower Columbia River salmonids and these harvest limits continue to be annually managed by the fisheries co-managers (TAC, 2015, 2017, 2018, 2019, 2020).

Tributary Fisheries

Recreational fisheries in the tributaries of the Columbia and Snake rivers are managed by Idaho, Washington, and Oregon for their respective waters. Tribes also regulate the tributary fisheries under their respective jurisdiction. NMFS has reviewed and approved various terminal-area state and tribal fisheries under the ESA.

Marine Mammal Protection Act

Due to years of pinniped predation on salmonid fish stocks in Puget Sound, WA, Congress amended the MMPA in 1994 to include a new section, section 120 – Pinniped Removal Authority. This section provides an exception to the MMPA "take" moratorium and authorizes the Secretary of Commerce to authorize the intentional lethal taking of individually identifiable pinnipeds that are having an adverse impact on the decline or recovery of salmonid fishery stocks.

To address the severity of pinniped predation at Bonneville Dam, NMFS has issued the states of Oregon, Washington, and Idaho (states) five MMPA section 120 authorizations (2008, 2011, 2012, 2016, and 2019[15]). Under these authorizations, the states have removed (transferred and killed) 238 California sea lions. The authorization at Bonneville Dam expires on June 28, 2021. Removal of sea lions at Bonneville Dam has protected (fish escaping sea lion predation) an estimated 12,516 to 50,064 salmon and steelhead (ODFW 2019).

To address the severity of pinniped predation throughout the Columbia River basin, in December of 2018[16] Congress passed the Endangered Salmon Predation Prevention Act, which amended section 120(f) of the MMPA. This amendment specified that any sea lion in the mainstem of the Columbia River from river mile 112 to river mile 292, or in any tributary within the state of Washington and Oregon that includes spawning habitat for species of salmon or steelhead, is deemed to be individually identifiable and having an adverse impact because of their ability to eat salmon and steelhead migrating to their spawning habitats in Oregon, Washington, and Idaho. This change reduced restrictions for removing predatory sea lions in the Columbia River and tributaries and allows for the removal of Steller sea lions in addition to California sea lions.

[15] Revised MMPA Section 120 Authorization letter from Barry Thom, National Marine Fisheries Service, to Kelly Susewind, Washington Department of Fish and Wildlife; Curtis Melcher, Oregon Department of Fish and Wildlife; and Ed Schriever, Idaho Department of Fish and Game; April 17, 2019.

[16] Public Law 115-329, the Endangered Salmon Predation Prevention Act.

On August 14, 2020, NMFS issued a permit under section 120(f) of the MMPA authorizing the applicant states and tribes (eligible entities[17]) to remove (i.e., to intentionally take, by lethal methods) California sea lions and Steller sea lions in select areas of the Columbia River basin. Steller sea lion removals at Bonneville Dam began in the fall of 2020. Under this permit, as of May 14, 2021, the states and tribes have removed 20 Steller sea lions and 29 California sea lions. The MMPA section 120(f) permit expires on August 14, 2025.

Management action under this authorization is expected to reduce pinniped predation on adult UCR spring-run Chinook and UCR steelhead in the Lower Columbia River. Given the logistical challenges of removing sea lions and other uncertainties, the magnitude of this expected reduction in pinniped predation is uncertain. NMFS[18] estimated that the MMPA section 120(f) sea lion removal program may protect (fish escaping sea lion predation) 13,089 to 78,533 salmon and steelhead over the next 5 years (2020 through 2025).

Listing Factor D Conclusion

When taken together, regulatory mechanisms for water quantity, fish passage in tributary streams, floodplain restoration in the Lower Columbia resulting from CRS biological opinion, and harvest management have slightly decreased the risk to the four listed Lower Columbia River species' persistence. Regulatory mechanisms in place for harvest are adequate and are reducing harvest impacts on most of the listed lower Columbia River Chinook salmon and lower Columbia River coho, with the exception of fall and bright fall-run components of the LCR Chinook Salmon ESU, where harvest rates are modestly trending upward in recent years (Ford 2022). This is discussed in greater detail in Listing Factor B. There remain concerns regarding the adequacy of regulatory mechanisms for the aforementioned fall and bright fall-run components of the LCR Chinook Salmon ESU.

Despite this slight improvement, there remain concerns regarding continued risk from other regulatory mechanisms, such as the CWA (that influences both water quality and Columbia River mainstem conditions), state and federal forest practices (influencing riparian forest cover), and FERC on high head dam passage. The regulatory inadequacy of forest management and water quality protection in particular (other than the cold water refugia plan of the Columbia River), when coupled with climate change suggest that risk of inadequate regulation may be increasing for these resources.

Listing Factor E: Other natural or manmade factors affecting species' continued existence

Climate Change

Major ecological realignments are already occurring in response to climate change (Crozier et al.

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17 Eligible Entities: Oregon Department of Fish and Wildlife, the Washington Department of Fish and Wildlife, the Idaho Department of Fish and Game, on behalf of their respective states; the Nez Perce Tribe, the Confederated Tribes of the Umatilla Indian Reservation, the Confederated Tribes of the Warm Springs Reservation of Oregon, the Confederated Tribes and Bands of the Yakama Nation; and the Willamette Committee.

18 NMFS, August 14, 2020. Environmental Assessment: Reducing Predation Impacts on At-Risk Fish by California and Steller Sea Lions in the Columbia River Basin.

2019). As observed by Seigel and Crozier in 2019, long-term trends in warming have continued at global, national and regional scales. Globally, 2014-2018 were the 5 warmest years on record, both on land and in the ocean (2018 was the 4th warmest). Events such as the 2013-2016 marine heatwave (Jacox et al. 2018) have been attributed directly to anthropogenic warming in the annual special issue of Bulletin of the American Meteorological Society on extreme events (Herring et al. 2018). Global warming and anthropogenic loss of biodiversity represent profound threats to ecosystem functionality. These two factors are often examined in isolation, but likely have interacting effects on ecosystem function (Seigel and Crozier 2019). Conservation strategies now need to account for geographical patterns in traits sensitive to climate change, as well as climate threats to species-level diversity.

To provide such information, Crozier et al. 2019, conducted a climate vulnerability assessment that included all anadromous Pacific salmon and steelhead (*Oncorhynchus* spp.) population units listed under the U.S. Endangered Species Act. Using an expert-based scoring system, they ranked 20 attributes for the 28 listed units and 5 additional units. Attributes captured biological sensitivity, or the strength of linkages between each listing unit and the present climate; climate exposure, or the magnitude of projected change in local environmental conditions; and adaptive capacity, or the ability to modify phenotypes to cope with new climatic conditions. Each listing unit was then assigned one of four vulnerability categories. Five Chinook, one coho, and one sockeye salmon DPSs ranked very high in total vulnerability to climate change due to a combination of high and very high scores for sensitivity and exposure. Bootstrap analyses indicated that two additional DPSs, Southern Oregon/Northern California Coast coho and Mid-Columbia spring-run Chinook, were borderline between high and very high. Among species, Chinook salmon had the highest vulnerability rankings overall (mostly very high and high rankings), followed by coho and sockeye. Steelhead and chum DPS scores were generally lower and nearly equally spread across high and moderate vulnerability categories. Units ranked most vulnerable overall were the California Central Valley Chinook, California and southern Oregon coho, the Snake River sockeye, interior Columbia Spring Chinook, and Willamette River Basin Spring Chinook (Crozier et al. 2019).

Projected Climate Change

Climate change is systemic, influencing ocean temperatures, ocean salinity, ocean acidity, and the composition and presence of a vast array of oceanic species. Other systems are also being influenced by changing climatic conditions. Seigel and Crozier (2019) provide the following observations: As stream temperatures increase, many native salmonids face increased competition with more warm-water tolerant invasive species. Changes in flow regimes may alter the amount of habitat available for spawning. This could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence.

Along with warming stream temperatures and concerns about sufficient groundwater to recharge streams, Seigel and Crozier (2019) observe that a newer study projects nearly complete loss of existing tidal wetlands along the U.S. West Coast due to sea-level rise (Thorne et al. 2018). California and Oregon showed the greatest threat to tidal wetlands (100 percent), while 68 percent of Washington tidal wetlands are expected to be submerged. Coastal development and steep topography prevent horizontal migration of most wetlands, causing the net contraction of this crucial habitat.

Updated projections of change are similar to or greater than previous projections. NMFS is increasingly confident in our projections because every year brings stronger validation of previous predictions in both physical and biological realms. Actions that retain and restore habitat complexity, increase access to climate refuges (both flow and temperature), and improve growth opportunities in both freshwater and marine environments are strongly advocated in the recent literature (Seigel and Crozier 2019).

Impacts on Salmon

As Seigel and Crozier (2019) describe, for salmon, correlations between freshwater and marine survival have important consequences for population dynamics. Synchrony between terrestrial and marine environmental conditions (e.g., coastal upwelling, precipitation, and river discharge) has increased in spatial scale, causing the highest levels of synchrony in the last 250 years (Black et al. 2018). Salmon productivity (recruits/spawner) has also become more synchronized across 24 wild Chinook populations from Oregon to the Yukon (Dorner et al. 2018). Contrary to previous summaries, which found that northern and southern stocks had inverse responses to ocean temperatures, the current analysis found positive pairwise correlations between nearly all stocks. Although a few populations tended to be less correlated with others, there was no latitudinal trend in correlations. Nearly all listing units faced high exposures to projected increases in stream temperature, sea surface temperature, and ocean acidification, but other aspects of exposure peaked in particular regions. Anthropogenic factors, especially migration barriers, habitat degradation, and hatchery influence, have reduced the adaptive capacity of most steelhead and salmon populations. (Crozier et al. 2019).

At the individual scale, climate impacts in one life stage generally affect body size or timing in the next life stage and can be negative across multiple life stages (Healey 2011; Wade et al. 2013; Wainwright and Weitkamp 2013). Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool-season precipitation could influence migration cues for fall and spring adult migrants, such as coho and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds. Changes in hydrological regime, such as a shift from mostly snow to more rain, could drive changes in life history, potentially threatening diversity within an ESU (Beechie et al. 2006). Changes in summer temperature and flow will affect both juvenile and adult stages in some populations, especially those with yearling life histories and summer migration patterns (Quinn 2005; Crozier and Zabel 2006; Crozier et al. 2010).

At the population level, the ability of organisms to genetically adapt to climate change depends on how selection on multiple traits interact and whether those traits are linked genetically. Upper thermal limits and hypoxia tolerance are likely to be important traits in determining the effects of climate change on fish populations. For example, Healy et al. (2018) compared genetic diversity associated with thermal and hypoxia tolerance in two sub-species of Atlantic killifish, *Fundulus heteroclitus*, which have previously been shown to differ in these traits. Single nucleotide polymorphisms (SNPs) were found related to each trait independently, but none were shared between both traits. These results suggest that, at least in Atlantic killifish, thermal and hypoxia tolerance are genetically independent traits. At present, more than half of all anadromous Pacific salmon and steelhead DPSs remaining in the contiguous U.S. are threatened with extinction.

Suboptimal climate conditions within the historical range of climate variability have been associated with detectable declines in many of these DPSs, highlighting their sensitivities to climatic drivers. In some cases, the synergistic effects of suboptimal climate conditions and intense anthropogenic stressors precipitated the population declines that led to these listing decisions (Crozier et al. 2019).

Another potential limitation in the ability of salmon populations to adapt to climate change is the reduced level of existing genetic diversity compared to historic levels. Johnson et al. (2018) compared genetic variation in Chinook salmon from the Columbia River basin between contemporary and ancient samples. A total of 84 samples determined to be Chinook salmon were collected from vertebrae found in ancient middens and compared to 379 contemporary samples. Results suggest a decline in genetic diversity, as demonstrated by a loss of mitochondrial haplotypes and reductions in haplotype and nucleotide diversity. Genetic losses in this comparison appeared larger for Chinook from the mid-Columbia than those from the Snake River basin.

Relative to sockeye, three or four-year cycles are common in sockeye salmon stocks, with returns varying by an order of magnitude or more between high and low points in the cycles. Longer-term cycles are also apparent but less regular. These seem to be associated with changes in ocean conditions that affect survival during the feeding migration (Phillips and Perez-Ramirez, eds. 2019); accordingly, shifting ocean conditions may shift the range of the highs and lows downward.

<u>Terrestrial and Ocean Conditions and Marine Survival</u>
The following is excerpted from Seigel and Crozier (2019), who present a review of recent scientific literature evaluating the effects of climate change.

"Cooper et al. (2018), examined whether the magnitude of low river flows in the western U.S., which generally occur in September or October, are driven more by summer conditions or the prior winter's precipitation. They found that while low flows were more sensitive to summer evaporative demand than to winter precipitation, interannual variability in winter precipitation was greater. Malek et al. (2018b) predicted that summer evapotranspiration is likely to increase in conjunction with declines in snowpack and increased variability in winter precipitation. Their results suggest that low summer flows are likely to become lower, more variable, and less predictable."

The effect of climate change on ground water availability is likely to be uneven. Sridhar et al. (2018) coupled a surface-flow model with a ground-flow model to improve predictions of surface water availability with climate change in the Snake River Basin. Combining the VIC and MODFLOW models (VIC-MF), they predicted flow for 1986-2042. Comparisons with historical data show improved performance of the combined model over the VIC model alone. Projections using RCP 4.5 and 8.5 emission scenarios suggested an increase in water table heights in downstream areas of the basin and a decrease in upstream areas. Such assessments will help stakeholders manage water supplies more sustainably.

Forests

Climate change will impact forests of the western U.S., which dominate the landscape of many watersheds in the region. Forests are already showing evidence of increased drought severity, forest fire, and insect outbreak. Additionally, climate change will affect tree reproduction, growth, and phenology, which will lead to spatial shifts in vegetation. Halofsky et al. (2018b) projected that the largest changes will occur at low- and high-elevation forests, with expansion of low-elevation dry forests and diminishing high-elevation cold forests and subalpine habitats. Halofsky et al. (2018a) also assessed climate adaptation strategies for forest management in the region.

Forest fires affect salmon streams by altering sediment load, channel structure, and stream temperature through the removal of canopy. Holden et al. (2018) examined environmental factors contributing to observed increases in the extent of forest fires throughout the western U.S. They found strong correlations between the number of dry-season rainy days and the annual extent of forest fires, as well as a significant decline in the number of dry-season rainy days over the study period (1984-2015). Consequently, predicted decreases in dry-season precipitation, combined with increases in air temperature, will likely contribute to the existing trend of more extensive and severe forest fires.

Beyond environmental factors, management practices have left forests more dense and less diverse, which increases vulnerability to fire damage. Attempting to restore forest composition to a state more similar to historical conditions would likely increase fire resiliency, though methods to do so are often contentious (Johnston et al. 2018).

Agne et al. (2018) reviewed the literature on insect outbreaks and other pathogens affecting coastal Douglas-fir forests in the Pacific Northwest and examined how future climate change may influence disturbance ecology. They suggest that Douglas-fir beetle and black stain root disease could become more prevalent with climate change, while other pathogens will be more affected by management practices. Agne et al. (2018) also suggested that due to complex interacting effects of disturbance and disease, climate impacts will differ by region and forest type."

Freshwater environments

As cited in Seigel and Crozier (2019), Isaak et al. (2018) examined recent trends in stream temperature across the Western U.S. using a large regional dataset. Stream warming trends paralleled changes in air temperature and were pervasive during the low-water warm seasons of 1996-2015 (0.18-0.35°C/decade) and 1976-2015 (0.14-0.27°C/decade). Their results show how continued warming will likely affect the cumulative temperature exposure of migrating sockeye salmon (*O. nerka*) and the availability of suitable habitat for brown trout (*Salmo trutta*) and rainbow trout (*O. mykiss*). Isaak et al. (2018) concluded that most stream habitats will likely remain suitable for salmonids in the near future, with some becoming too warm.

Streams with intact riparian corridors that lie in mountainous terrain are likely to be more resilient to changes in air temperature. These areas may provide refuge from climate change for a number of species, including Pacific salmon. Krosby et al. (2018) identified potential stream refugia throughout the Pacific Northwest based on a suite of features thought to reflect the ability of streams to serve as such refuges. Analyzed features include large temperature gradients, high canopy cover, large relative stream width, low exposure to solar radiation, and low levels of human modification. They created an index of refuge potential for all streams in the region, with mountain area streams scoring highest. Flat lowland areas, which commonly contain migration corridors, were generally scored lowest, and thus were prioritized for conservation and restoration.

Seigel and Crozier (2019) express concern that, for some salmon populations, climate change may drive mismatches between juvenile arrival timing and prey availability in the marine environment. However, phenological diversity can contribute to metapopulation-level resilience by reducing the risk of a complete mismatch. Carr-Harris et al. (2018) explored the phenological diversity of marine migration timing in relation to zooplankton prey for sockeye salmon (*O. nerka*) from the Skeena River of Canada. They found that sockeye migrated over a period of more than 50 days. Populations from higher elevation and further inland streams arrived in the estuary later, and different populations encountered distinct prey fields. They recommended that managers maintain and augment such life-history diversity.

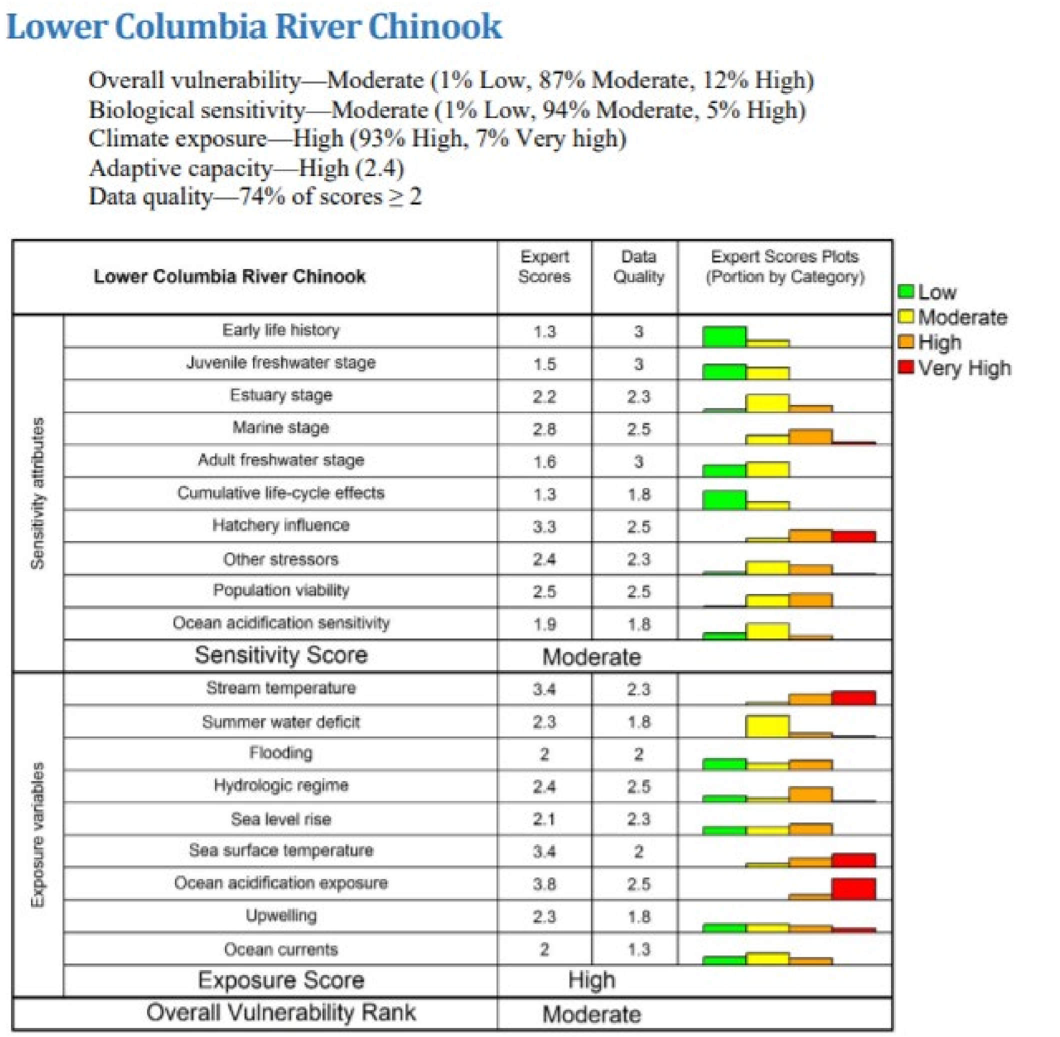
Marine survival

Marine survival of salmonids is affected by a complex array of factors, including prey abundance, predator interactions, and the physical condition of salmon within the marine environment. Seigel and Crozier 2019, observe that changes in marine temperature are likely to have a number of physiological consequences on fishes themselves. For example, in a study of small planktivorous fish, Gliwicz et al. 2018 found that higher ambient temperatures increased the distance at which fish reacted to prey. Numerous fish species (including many tuna and sharks) demonstrate regional endothermy, which in many cases augments eyesight by warming the retinas. However, Gliwicz et al. 2018 suggest that ambient temperatures can have a similar effect on fish that do not demonstrate this trait. Climate change is likely to reduce the availability of biologically essential omega-3 fatty acids produced by phytoplankton in marine ecosystems. Loss of these lipids may induce cascading trophic effects, with distinct impacts on different species depending on compensatory mechanisms (Gourtay et al. 2018). Reproduction rates of many marine fish species are also likely to be altered with temperature (Veilleux et al. 2018). The ecological consequences of these effects and their interactions add complexity to predictions of climate change impacts in marine ecosystems.

Species Specific Climate Effects (from Crozier et al. 2019)

Climate Effects on Abundance and Distribution of Lower Columbia River Chinook

LCR Chinook had a high exposure score for summer stream temperature. If spring-run Chinook adults or yearling juveniles are restricted to lower river reaches due to lower flows, summer temperatures might become a limiting factor. This ESU scored moderate for hydrologic regime shift, indicating that reduced snowmelt and higher winter flows may affect these fish in some areas. To access headwater areas, spring-run Chinook rely upon high flows from snowmelt during April-June; thus, a reduced spring freshet might require earlier migration. The timing of river entry for the spring run is triggered by a rising thermograph (Keefer et al. 2008).



Lower Columbia River Chinook

Overall vulnerability—Moderate (1% Low, 87% Moderate, 12% High)
Biological sensitivity—Moderate (1% Low, 94% Moderate, 5% High)
Climate exposure—High (93% High, 7% Very high)
Adaptive capacity—High (2.4)
Data quality—74% of scores ≥ 2

	Lower Columbia River Chinook	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.3	3	
	Juvenile freshwater stage	1.5	3	
	Estuary stage	2.2	2.3	
	Marine stage	2.8	2.5	
	Adult freshwater stage	1.6	3	
	Cumulative life-cycle effects	1.3	1.8	
	Hatchery influence	3.3	2.5	
	Other stressors	2.4	2.3	
	Population viability	2.5	2.5	
	Ocean acidification sensitivity	1.9	1.8	
	Sensitivity Score	Moderate		
Exposure variables	Stream temperature	3.4	2.3	
	Summer water deficit	2.3	1.8	
	Flooding	2	2	
	Hydrologic regime	2.4	2.5	
	Sea level rise	2.1	2.3	
	Sea surface temperature	3.4	2	
	Ocean acidification exposure	3.8	2.5	
	Upwelling	2.3	1.8	
	Ocean currents	2	1.3	
	Exposure Score	High		
Overall Vulnerability Rank		Moderate		

Figure 6. An Image of the Chinook Climate Vulnerability Table from Crozier et al., 2019.

If spring temperatures are higher and spring flows lower, adults may move into headwater reaches sooner than normal. It is conceivable that their energy stores might be insufficient to sustain them from summer to the early fall spawning period when temperatures decline. A higher-resolution study of specific habitats is needed to clarify the extent of this risk. Fall-run adults return to freshwater at an advanced state of maturation during September-October. For these fish, river entry is triggered in part by a falling thermograph, so warmer temperatures may delay arrival at spawning grounds or require fish to hold and spawn in waters at lethal or sublethal temperatures, resulting in direct or indirect mortality (Schreck et al. 2013; Keefer et al. 2008)[19]. There is some indication that holding in sublethal temperatures can degrade the quality

[19] In these cases, only a small portion of the run would arrive at a time that would result in successful reproduction. Under historical conditions selection would adjust the population's run timing and other characteristics to better synchronize with the environment. The fear is that this change is happening too quickly and rather than the population gradually adjusting, selection may result in a dramatic reduction in population size, reduced genetic diversity, and a higher probability of demographic collapse. Pers. Comm. Jim Myers, NWFSC, 12/20/2021.

of both male and female gametes (McCullough et al. 2001; Lahnsteiner and Kletzl 2012). Late-fall adults from this DPS may be less subject to deleterious temperatures given the November timing of their freshwater entry. Timing of maturation and spawning strongly influences the susceptibility of different run types to climate change.

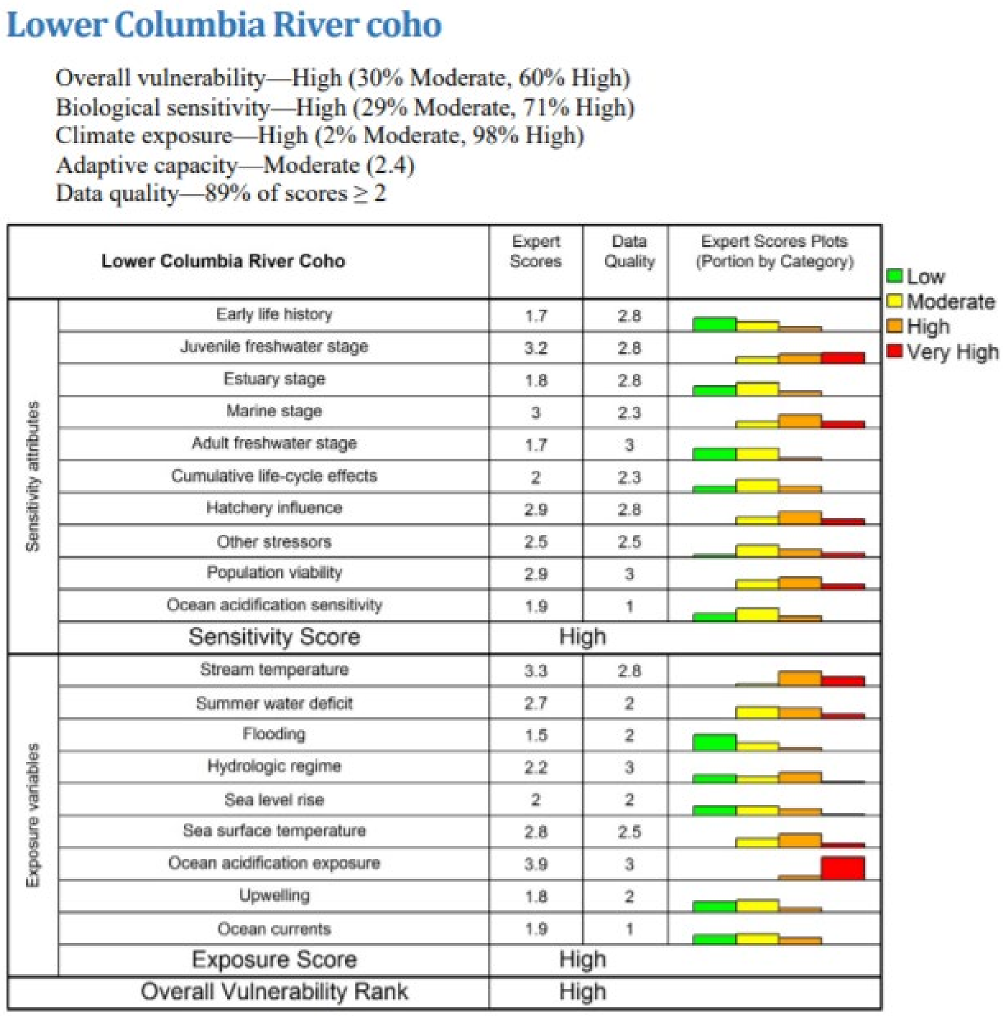
As for nearly all Chinook DPSs, warmer winter temperatures will likely accelerate embryonic development and emergence timing. Delayed spawning might reduce temperature effects on emergence timing. However, warmer developmental temperatures can still lead to a degraded condition in alevins (Fuhrman et al. 2018), which may have less yolk to tide them over until external food sources are available.

At present, we lack sufficient information on how stream productivity changes with warming temperature to determine whether bioenergetic constraints will be detrimental to salmon. Nevertheless, downstream migration is triggered by flow and facilitated by snowmelt in spring. Whether directly or indirectly, Lower Columbia River Chinook salmon juveniles will be affected by warmer stream temperatures, as well as by changing estuary and coastal ocean conditions (Daly and Brodeur 2015).

Lower Columbia River Chinook ranked high in adaptive capacity overall, largely because of high diversity in both juvenile and adult run timing across the ESU as a whole. This rank does not imply that specific populations might not be at higher risk, or that diversity within the ESU will not diminish in the future.

Climate Effects on Abundance and Distribution of Lower Columbia River Coho

In September, early returning adult coho may encounter seasonally warm temperatures or low flows that delay entry into spawning tributaries. However, adults will typically hold in estuaries or larger rivers and rapidly ascend tributaries to spawn when conditions become suitable (Clark et al. 2014). Seasonal drops in stream temperature and increases in discharge improve conditions for adult migration as well as egg incubation. Thus, incubating eggs of Lower Columbia River coho salmon are unlikely to be exposed to excessively warm temperatures or desiccation. Because coho juveniles typically spend at least one year in freshwater, they can be stressed by warm stream conditions or low flows in summer (Ebersole et al. 2009) and by floods that may displace them or reduce available habitat in winter (Nickelson et al. 1992). High ranks for sensitivity in the juvenile freshwater stage and for exposure to stream temperatures were reflective of these findings and resulted in the juvenile freshwater stage rank as a highly vulnerable life stage for Lower Columbia River coho. Though the quality of information was mixed, sensitivity in the marine stage is ranked high because of the relatively high certainty that exposure to changing marine conditions will occur, namely high levels of ocean acidification. However, data quality used to evaluate climate-related threats was limited, and future evidence may alter these rankings.



Lower Columbia River coho

Overall vulnerability—High (30% Moderate, 60% High)
Biological sensitivity—High (29% Moderate, 71% High)
Climate exposure—High (2% Moderate, 98% High)
Adaptive capacity—Moderate (2.4)
Data quality—89% of scores ≥ 2

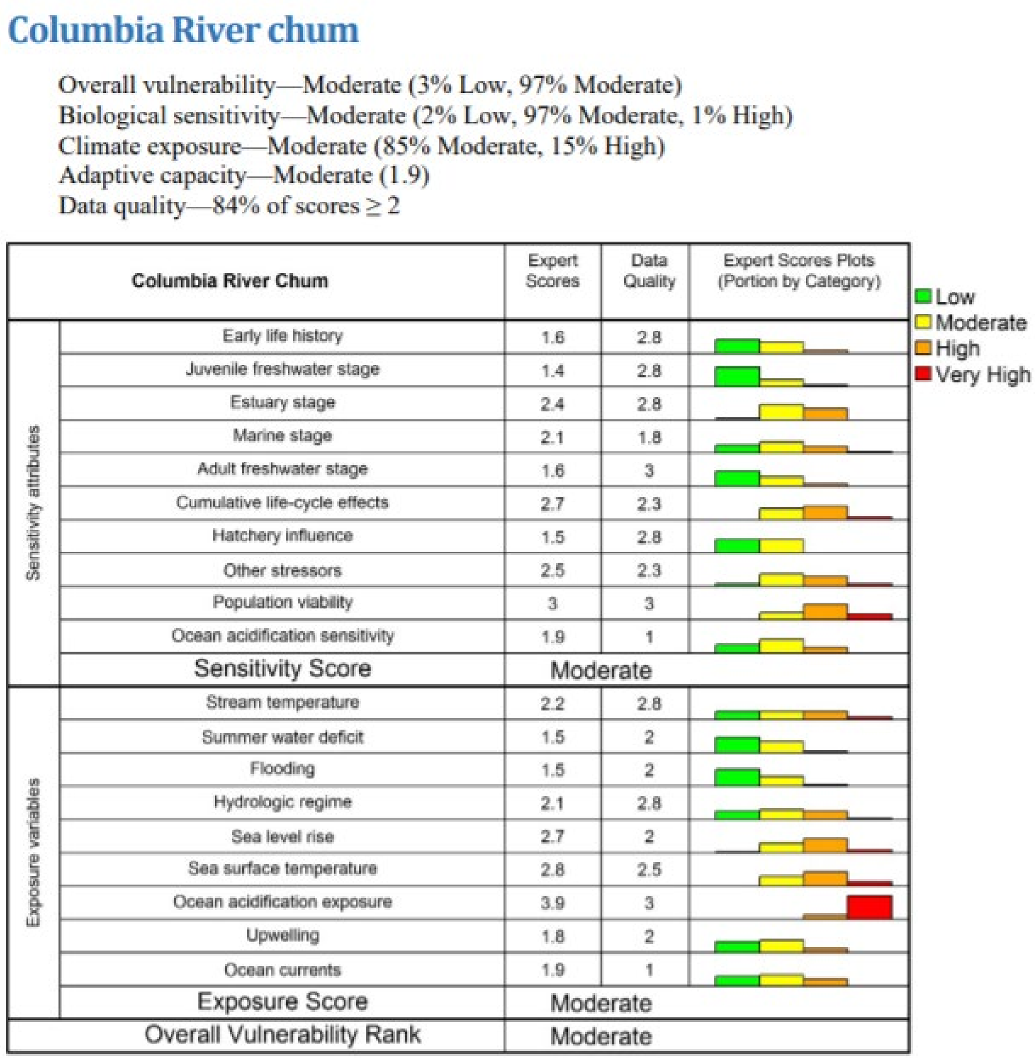
	Lower Columbia River Coho	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.7	2.8	
	Juvenile freshwater stage	3.2	2.8	
	Estuary stage	1.8	2.8	
	Marine stage	3	2.3	
	Adult freshwater stage	1.7	3	
	Cumulative life-cycle effects	2	2.3	
	Hatchery influence	2.9	2.8	
	Other stressors	2.5	2.5	
	Population viability	2.9	3	
	Ocean acidification sensitivity	1.9	1	
	Sensitivity Score	High		
Exposure variables	Stream temperature	3.3	2.8	
	Summer water deficit	2.7	2	
	Flooding	1.5	2	
	Hydrologic regime	2.2	3	
	Sea level rise	2	2	
	Sea surface temperature	2.8	2.5	
	Ocean acidification exposure	3.9	3	
	Upwelling	1.8	2	
	Ocean currents	1.9	1	
	Exposure Score	High		
Overall Vulnerability Rank		High		

Figure 7. An Image of the LCR Coho Climate Vulnerability Table from Crozier et al., 2019.

The adaptive capacity of Lower Columbia coho was ranked moderate. This ESU likely has an amount of flexibility in the juvenile rearing period similar to that of other coho. Adults in this ESU are less constrained in freshwater entry timing than California coho, and thus could potentially respond temporally to changing environmental conditions.

Climate Effects on Abundance and Distribution of Columbia River Chum
Given the late-autumn return and spawn timing of Columbia River chum, temperatures under climate change scenarios may not be limiting for adult pre-spawn survival or early life history. Furthermore, the preferential spawning in areas with groundwater seeps provides relatively constant incubation conditions and would moderate somewhat the effect from changes in temperature and precipitation. For chum that spawn in the lowermost reaches of Columbia River tributaries, sea-level changes could result in an expansion of areas influenced by saltwater intrusion or tidal (slack water) influence. Estuary and ocean temperature conditions may change more rapidly than incubation conditions, especially at groundwater seeps, and such changes

could leave juvenile migrants "out-of-sync" with nursery conditions. Accordingly, Columbia River chum ranked moderate in sensitivity to cumulative life-cycle effects.


Columbia River chum

Overall vulnerability—Moderate (3% Low, 97% Moderate)
Biological sensitivity—Moderate (2% Low, 97% Moderate, 1% High)
Climate exposure—Moderate (85% Moderate, 15% High)
Adaptive capacity—Moderate (1.9)
Data quality—84% of scores ≥ 2

	Columbia River Chum	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.6	2.8	
	Juvenile freshwater stage	1.4	2.8	
	Estuary stage	2.4	2.8	
	Marine stage	2.1	1.8	
	Adult freshwater stage	1.6	3	
	Cumulative life-cycle effects	2.7	2.3	
	Hatchery influence	1.5	2.8	
	Other stressors	2.5	2.3	
	Population viability	3	3	
	Ocean acidification sensitivity	1.9	1	
	Sensitivity Score	Moderate		
Exposure variables	Stream temperature	2.2	2.8	
	Summer water deficit	1.5	2	
	Flooding	1.5	2	
	Hydrologic regime	2.1	2.8	
	Sea level rise	2.7	2	
	Sea surface temperature	2.8	2.5	
	Ocean acidification exposure	3.9	3	
	Upwelling	1.8	2	
	Ocean currents	1.9	1	
	Exposure Score	Moderate		
Overall Vulnerability Rank		Moderate		

Figure 8. An Image of the CR Chum Climate Vulnerability Table from Crozier et al., 2019.

The small size of juvenile emergent chum migrating to the estuary makes them especially vulnerable to changing conditions in the lower river and estuary. For example, the quantity, type, and timing of zooplankton that juvenile chum feed upon while rearing in the estuary and nearshore environs may be dramatically altered under climate change, especially due to ocean acidification. During this early ocean entry period, chum salmon are most vulnerable to alterations in their environment.

Columbia River chum ranked moderate in adaptive capacity.

Climate Effects on Abundance and Distribution on Lower Columbia River Steelhead
LCR steelhead sensitivity ranks were moderate overall, reflecting substantial exposure to

changes in the freshwater environment tempered by tolerance to warm conditions and reproductive timing that avoids peak temperatures.

For Lower Columbia River steelhead, exposure to ocean acidification ranked very high, as it did for all species in this assessment. Very high scores for this attribute resulted from the strong magnitude of expected pH change, the broad spatial extent of ocean acidification, and the relatively high certainty in the direction of change. Exposure of this DPS was also ranked high for sea surface temperature, reflecting the broad spatial extent of this attribute. This DPS also ranked very high in exposure to stream temperature and moderate in exposure to summer water deficit. Lower Columbia River steelhead ranked low in exposure to nearshore attributes since juveniles tend to spend less time in the nearshore environment and migrate offshore relatively quickly. Nearshore exposure attributes for which this DPS ranked low included sea-level rise, upwelling, and ocean currents.

Wade et al. (2013) found that relative to other Pacific Northwest steelhead, Lower Columbia River steelhead had moderate exposure to expected changes in stream temperature and high exposure to changes in flow. Lower Columbia River steelhead was expected to have high sensitivity scores based on its habitat condition and threatened population status. Lower Columbia River steelhead juveniles migrate rapidly through the estuary in late spring and experience a short window of exposure to estuarine influence relative to other species (Fresh et al. 2005). Therefore, exposure was low for sea-level rise effects on the estuary. However, these juveniles use the estuary more extensively than many other juvenile steelhead. Therefore, this DPS had slightly higher exposure scores for sea-level rise than other Oregon and Washington stocks.

Lower Columbia River steelhead can tolerate a broad range of temperatures and has a very flexible life history. However, this DPS may have to shift migration or spawn timing in response to hydrologic regime change effects (Wade et al. 2013). Overall, this DPS ranked high in adaptive capacity.

Lower Columbia River steelhead

Overall vulnerability—Moderate (2% Low, 92% Moderate, 6% High)
Biological sensitivity—Moderate (3% Low, 93% Moderate, 3% High)
Climate exposure—High (98% High, 2% Very high)
Adaptive capacity—High (2.3)
Data quality—84% of scores ≥ 2

	Lower Columbia River Steelhead	Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.5	2.8	
	Juvenile freshwater stage	2.1	2.8	
	Estuary stage	1.7	2.3	
	Marine stage	2	2	
	Adult freshwater stage	1.6	2.8	
	Cumulative life-cycle effects	1.8	2	
	Hatchery influence	3.2	2.5	
	Other stressors	2.7	2.5	
	Population viability	2.5	2.8	
	Ocean acidification sensitivity	1.9	1.8	
	Sensitivity Score	Moderate		
Exposure variables	Stream temperature	3.4	2.5	
	Summer water deficit	2.6	2	
	Flooding	2	2	
	Hydrologic regime	1.7	2.8	
	Sea level rise	1.8	2	
	Sea surface temperature	3.2	2.3	
	Ocean acidification exposure	3.9	3	
	Upwelling	1.6	1.8	
	Ocean currents	1.8	1	
	Exposure Score	High		
	Overall Vulnerability Rank	Moderate		

Low
Moderate
High
Very High

Figure 9. An Image of the LCR Steelhead Climate Vulnerability Table from Crozier et al., 2019.

Invasive species

Invasive species can increase the risk of listed species survival due to predation, displacement, or competition. Non-indigenous species compete directly and indirectly for resources, significantly altering food webs and trophic structure, and potentially altering evolutionary trajectories (Sanderson et al. 2009; NMFS 2010). Brook trout are known competitors and American shad may impact food webs (Naiman et al. 2012, Sanderson et al. 2009; NMFS 2010).

Shad

Millions of shad return annually to the Columbia River basin. Past studies have noted potential food web impacts on salmonids. Recent studies have noted that juvenile Chinook eat shad (Haskell 2017), and have attempted to quantify marine derived nutrient inputs into the ecosystem by shad (Haskell 2017, 2018; Twining 2017).

Brook trout

Brook trout are the most likely non-native competitor higher in the watershed. No new studies documenting brook trout competition have come out in the last 5 years.

Hatchery Effects – Summary of Science on Hatchery Impacts

The effects of hatchery fish on the status of an ESU or DPS depends upon which of the four key attributes -- abundance, productivity, spatial structure, and diversity -- are currently limiting the ESU/DPS, and how the hatchery fish within the ESU/DPS affect each of the attributes (70 FR 37204). Hatchery programs can provide short-term demographic benefits, such as increases in abundance during periods of low natural abundance. They also can help preserve genetic resources until limiting factors can be addressed. However, the long-term use of artificial propagation may pose risks to natural productivity and diversity. The magnitude and type of the risk depend on the status of affected populations and on specific practices in the hatchery program.

LCR Chinook Salmon

Hatchery managers have continued to implement and monitor changes in LCR Chinook salmon hatchery management since the last 5-year review (Table 11). Although several measures have been implemented to reduce risk, the proportion of hatchery fish on the spawning grounds (pHOS) remains high in the Coastal and Gorge MPGs. NMFS has completed ESA consultations that have resulted in changes to the programs to reduce hatchery effects on natural-origin populations within the ESU (NMFS 2007, 2017a). We conclude that hatchery effects continue to present risks to the persistence of the LCR Chinook salmon ESU, but they are likely less of a risk compared to the last 5-year review.

Table 11. ESA Status of hatchery programs within the LCR Chinook salmon ESU.

Program Stock Origin	Program	Run	Watershed Location of Release (State)	Currently Listed?	HGMP/ TRMP Status
Big Creek Tule	Big Creek Tule	Fall	Big Creek (OR)	Yes	C
	Astoria High School Tule	Fall	Youngs Bay (OR)	Yes	C
	Warrenton High School Tule	Fall	Youngs Bay (OR)	Yes	C
Klaskanine	Klaskanine Tule	Fall	Klaskanine River (OR)	Yes	C
Cowlitz Tule	Cowlitz River	Fall	Cowlitz River (WA)	Yes	C
North Fork Toutle	North Fork Toutle	Fall	North Fork Toutle River (WA)	Yes	C
Kalama	Kalama River	Fall	Kalama River (WA)	Yes	C
Washougal	Washougal River	Fall	Washougal River (WA)	Yes	C
	Deep River Net Pens	Fall	Deep River (WA)	Yes	C
Spring Creek	Spring Creek NFH	Fall	Columbia River (WA)	Yes	C
Cowlitz River	Cowlitz – Cispus River	Spring	Cowlitz River (WA)	Yes	M
	Cowlitz – Upper Cowlitz	Spring	Cowlitz River (WA)	Yes	M

Program Stock Origin	Program	Run	Watershed Location of Release (State)	Currently Listed?	HGMP/ TRMP Status
	Friends of the Cowlitz	Spring	Cowlitz River (WA)	Yes	M
	Cathlamet Channel Net Pens	Spring	Columbia River (WA)	Yes	C
	Deep River Net Pens	Spring	Deep River (WA)	No	C
Kalama	Kalama River	Spring	Kalama River (WA)	Yes	C
Lewis River	Lewis River	Spring	North Fork Lewis River	Yes	M
	Fish First Spring Chinook	Spring	North Fork Lewis River	Yes	M
Sandy River	Sandy River	Spring	Sandy River (OR)	Yes	C
Bonneville	Bonneville Tule	Fall	Tanner Creek (OR)	Yes	C
Select Area Brights	Clatsop Co. Fisheries	Fall	Youngs Bay (OR)	No	U
Willamette River	Clatsop Co. Fisheries	Spring	Young Bay and Tongue Point (OR)	No	C
Carson	Carson NFH	Spring	Wind River (WA)	No	C
	Little White Salmon NFH	Spring	Little White Salmon River (WA)	No	C
	Willard NFH	Spring	Little White Salmon River (WA)	No	C
Hood River	Hood River	Spring	Hood River (OR)	No	C
URB Fall Chinook	Little White Salmon NFH	Fall	Little White Salmon River	No	C
	Willard NFH	Fall	Little White Salmon River	No	C

[1]Program on hiatus. NFH = National Fish Hatchery; HGMP = Hatchery and Genetic Management Plan; C = Review under the ESA is complete; U = undergoing ESA review; M = HGMP has not been submitted or is being modified by the applicant.

CR Chum Salmon

Hatchery managers have continued to implement and monitor changes in chum hatchery management since the last 5-year review (Table 11). All of the hatchery programs in this ESU use integrated stocks developed to supplement natural production. The goal of these programs for chum salmon is conservation and rebuilding population abundances throughout the ESU, including getting sufficient returns of chum salmon to the Big Creek hatchery. Given the low numbers of hatchery chum salmon released throughout the ESU (approximately 500,000), the vast majority of spawning fish are of natural-origin (>90%; Ford 2022). Existing hatchery programs for chum salmon are important for the conservation and recovery of this ESU (NMFS 2017a). We conclude that risk to this ESU from hatchery programs is low.

Table 11. ESA Status of hatchery programs within the CR Chum Salmon ESU.

Program Stock Origin	Program	Run	Watershed Location of Release (State)	Currently Listed?	HGMP/ TRMP Status
Big Creek Tule	Big Creek Hatchery	Fall	Big Creek (OR)	Yes	C
Grays River	Grays River	Fall	Grays River (WA)	Yes	M
Ives Island	Washougal River Hatchery/Duncan Creek	Fall	Duncan Creek (WA)	Yes	M

HGMP = Hatchery and Genetic Management Plan; C = Review under the ESA is complete; U = undergoing ESA review; M = HGMP has not been submitted or is being modified by the applicant.

LCR Coho Salmon

Hatchery managers have continued to implement and monitor changes in LCR coho hatchery management since the last 5-year review (Table 12). Although several measures have been implemented to reduce risk, the proportion of hatchery fish on the spawning grounds (pHOS) remains high in all the MPGs. NMFS has completed ESA consultations that have contributed to program changes to reduce hatchery effects on natural-origin populations within the ESU (NMFS 2017a). We conclude that hatchery effects continue to present risks to the persistence of the LCR Coho Salmon ESU, but they are likely less of a risk compared to the last 5-year review.

Table 12. ESA Status of hatchery programs within the LCR Coho Salmon ESU.

Program Stock Origin	Program	Run	Watershed Location of Release (State)	Currently Listed?	HGMP/ TRMP Status
Big Creek Coho	Big Creek Coho	Early	Big Creek (OR)	Yes	C
	Astoria High School Coho	Early	Youngs Bay (OR)	Yes	C
	Warrenton High School Coho	Early	Youngs Bay (OR)	Yes	C
Klaskanine	Clatsop County Fisheries/Klaskanine	Early	Klaskanine River (OR)	Yes	C
	Clatsop County Fisheries Net Pens	Early	Youngs Bay (OR)	Yes	C
Grays River	Grays River	Early	Grays River	Yes	C
	Peterson Coho Project	Early	Grays River	Yes	C
Cowlitz Type-N	Cowlitz Type-N Coho Program in Upper and Lower Cowlitz River	Type-N	Cowlitz River (WA)	Yes	M
	Cowlitz Game and Anglers Coho	Type-N	Cowlitz River (WA)	Yes	M
	Friends of the Cowlitz	Type-N	Cowlitz River (WA)	Yes	M
North Fork Toutle Type-S	North Fork Toutle Type-S	Type -S	North Fork Toutle River (WA)	Yes	C
Kalama Type-N	Kalama River	Type-N	Kalama River (WA)	Yes	C
Washougal	Washougal River	Fall	Washougal River (WA)	Yes	C
	Deep River Net Pens	Fall	Deep River (WA)	Yes	C
Lewis River	Lewis River Type-S	Type-S	North Fork Lewis River	Yes	M

Program Stock Origin	Program	Run	Watershed Location of Release (State)	Currently Listed?	HGMP/ TRMP Status
Type-S	Program		(WA)		
Lewis River Type-N	Lewis River Type-N	Type-N	North Fork Lewis River (WA)	Yes	M
	Fish First Type-N	Type-N	North Fork Lewis River (WA)	Yes	M
	Syverson Project Type-N	Type-N	Salmon Creek (WA)	Yes	M
Cedar Creek	Fish First Wild Coho	Type-N	Lewis River (WA)	Yes	M
Washougal Type-N	Washougal River Type-N	Type-N	Washougal River (WA)	Yes	C
Eagle Creek NFH	Eagle Creek NFH	Early	Eagle Creek (Clackamas River) (OR)	Yes	C
Sandy River	Sandy Hatchery	Early	Sandy River (OR)	Yes	C
Bonneville	Bonneville/Cascade/Oxbow Complex Coho	Early	Tanner Creek (OR)	Yes	C
Elochoman	Beaver Creek	Type-N	Elochoman River (WA)	No	C
	Deep River Net Pens	Early	Deep River (WA)	No	C
Lewis River Type-S	Deep River Net Pens	Type-S	Deep River (WA)	No	C
Eagle Creek	Eagle Creek NFH	Early	Eagle Creek (Clackamas River) (OR)	Yes	C

NFH = National Fish Hatchery; HGMP = Hatchery and Genetic Management Plan; C = Review under the ESA is complete; U = undergoing ESA review; M = HGMP has not been submitted or is being modified by the applicant.

LCR steelhead

Hatchery managers have continued to implement and monitor changes in LCR steelhead hatchery management since the last 5-year review (Table 13). Although several measures have been implemented to reduce risk, the proportion of hatchery fish on the spawning grounds (pHOS) remains high in all the MPGs. NMFS has completed ESA consultations that have contributed to program changes. These program changes are expected to reduce hatchery effects on natural-origin populations within the ESU (NMFS 2017a). We conclude that hatchery effects continue to present risks to the persistence of the LCR Steelhead DPS, but they are likely less of a risk compared to the last 5-year review.

Table 13. ESA Status of hatchery programs within the LCR Steelhead DPS.

Program Stock Origin	Program	Run	Watershed Location of Release (State)	Currently Listed?	HGMP/ TRMP Status
Cowlitz River	Cowlitz Trout Hatchery Late Winter-run	Late	Cowlitz River (WA)	Yes	M
	Upper Cowlitz Wild	Late	Upper Cowlitz River (WA)	Yes	M
	Tilton River Wild	Late	Tilton River (WA)	Yes	M
Kalama River	Kalama River Wild Winter-run	Late	Kalama River (WA)	Yes	C

Program Stock Origin	Program	Run	Watershed Location of Release (State)	Currently Listed?	HGMP/ TRMP Status
Kalama River	Kalama River Wild Summer-run	Summer	Kalama River (WA)	Yes	C
Clackamas River	Clackamas Hatchery Late Winter	Late	Clackamas River (OR)	Yes	C
	Eagle Creek NFH Winter Steelhead	Late	Eagle Creek (Clackamas River) (OR)	No	C
Sandy River	Sandy Hatchery Late Winter	Late	Sandy River (OR)	Yes	C
Hood River	Hood River Winter-run	Late	Hood River (OR)	Yes	C
Lewis River	Lewis River Wild Late-run	Late	Lewis River (WA)	Yes	M
Eagle Creek	Eagle Creek NFH	Early	Eagle Creek (Clackamas River) (OR)	No	C
Kalama River	Coweeman Winter	Mix	Coweeman River (WA)	No	C
	Klineline Winter	Mix	Salmon River (WA)	No	C
	Kalama Winter	Mix	Kalama River (WA)	No	C
Kalama River	Kalama River Skamania Summer	Summer	Kalama River (WA)	No	C
Skamania Hatchery Winter	Washougal Winter	Mix	Washougal River (WA)	No	C
	Rock Creek Winter	Mix	Rock Creek (WA)	No	C
Skamania Hatchery Summer	South Toutle Summer	Summer	South Fork Toutle River (WA)	No	C
Skamania Hatchery	Washougal Summer	Summer	Washougal River (WA)	No	C
Clackamas Summer	Clackamas Summer	Summer	Clackamas River (OR)	No	C
Sandy River Summer	Sandy River Summer	Summer	Sandy River (OR)	No	C
Cowlitz River	Cowlitz River Summer	Summer	Cowlitz River (WA)	No	M
Lewis River	Lewis River Summer	Summer	Lewis River (WA)	No	M
	Echo Net Pens Summer	Summer	Lewis River (WA)	No	M
Lewis River	Lewis River Winter	Mix	Lewis River (WA)	No	M

NFH = National Fish Hatchery; HGMP = Hatchery and Genetic Management Plan; C = Review under the ESA is complete; U = undergoing ESA review; M = HGMP has not been submitted or is being modified by the applicant.

Listing Factor E Conclusion

<u>Climate Change</u>

The effects of climate change extend to every habitat and every life history phase of listed LCR salmonids. Effects range from decreasing predictability of annual events such as spring freshets and timing of prey abundance, to increasing stream and ocean temperatures, and setting the stage for increased competition with warm-water adapted nonnative species. These challenges tend to amplify and exacerbate other threats experienced by listed LCR salmonids and are expected to increase in magnitude as climate change progresses.

Invasive Species
The level of risk posed to LCR Chinook, CR chum, LCR coho, and LCR steelhead has not increased since our 2016 5-year review.

Hatchery Effects
Although several measures have been implemented to reduce risk, the proportion of hatchery fish on the spawning grounds (pHOS) remains high in all MPGs for both LCR coho and LCR steelhead, and also remains high in the Coastal and Gorge MPGs for LCR Chinook salmon. We conclude that while hatchery effects continue to present risks to the persistence of all four ESA-listed Lower Columbia River species, hatchery effects are likely less of a risk compared to the last 5-year review because NMFS has completed ESA consultations that have contributed to program changes, such as the implementation of the Big Creek Chum Salmon Program (NMFS 2017a). Such programs are expected to continue to reduce hatchery effects on natural-origin populations of the four ESA-listed Lower Columbia River salmon and steelhead species.

2.4 Synthesis

The ESA defines an endangered species as one that is in danger of extinction throughout all or a significant portion of its range, and a threatened species as one that is likely to become an endangered species in the foreseeable future throughout all or a significant portion of its range. Under ESA section 4(c)(2), we must review the listing classification of all listed species at least once every five years. While conducting these reviews, we apply the provisions of ESA section 4(a)(1) and NMFS' implementing regulations at 50 CFR part 424.

To determine if a reclassification is warranted, we review the status of the species and evaluate the five factors identified in ESA section 4(a)(1): (1) the present or threatened destruction, modification, or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific, or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; and (5) other natural or man-made factors affecting a species continued existence. We then make a determination based solely on the best available scientific and commercial information, taking into account efforts by states and foreign governments to protect the species.

Viability Summary

For the LCR Chinook Salmon ESU, some populations have exhibited improvements in abundance, but of greater concern is the large number of DIPs (10) that either had no abundance information (presumed near zero) or exist at very low abundances (Ford 2022). Although the viability of this ESU has increased, all of the Coastal and Gorge MPG fall-run populations (except the Lower Gorge DIP) fall within the high- to very high-risk categories. Similarly, with the exception of the Sandy River spring-run DIP, all of the spring-run DIPs in the Cascade and Gorge MPGs are at high- to very high-risk, with a number of populations at or near zero, while others may only persist through hatchery supplementation. According to Ford 2022, there has been little change in the biological status of Chinook salmon populations in the Lower Columbia River Chinook salmon ESU since the last review. Many of the populations in this ESU remain at high risk, and the ESU remains at moderate risk of extinction overall.

For the CR Chum Salmon ESU, some populations have increased in abundance during this review period. However, improvements in a few populations do not warrant a change in the risk category for the ESU as a whole, especially given the uncertainty regarding climatic effects in the near future (Ford 2022; Myers, personal communication, May 11, 2022). The viability of this ESU is relatively unchanged since the last review and therefore remains at moderate to high risk of extinction.

For the individual populations within the LCR Coho Salmon ESU, overall abundance trends for the ESU are generally negative. Natural spawner and total abundances have decreased in almost all DIPs. The risk of extinction spans the full range from low to very high. Overall, the LCR Coho Salmon ESU's risk of extinction was found to have increased since the previous review period. The NWFSC determined the ESU remains at moderate risk of extinction (Ford 2022).

For the LCR Steelhead DPS, the majority of winter-run steelhead DIPs continue to persist at low levels of abundance (100s of fish), with the exception of the Clackamas and Sandy River DIPs, which have abundances in the low 1,000s. Although the 5-year geometric abundance means are near recovery plan goals for many populations, the recent trends are negative. A number of populations exhibited increases in their 5-year geometric mean while others still remain depressed, and neither the winter nor summer-run MPGs are near viability for the Gorge. It is not possible to determine the risk status of this DPS given the uncertainty in abundance estimates for nearly half of the DIPs. Additionally, nearly all of the DIPs for which there is abundance data exhibited a negative abundance trend in 2018 and 2019. Given these concerns, the NWFSC identifies the LCR Steelhead DPS at a moderate risk of extinction (Ford 2022).

Listing Factor Summary

Listing Factor A: Habitat

Habitat restoration has occurred throughout the geography of the LCR Chinook salmon ESU, CR Chum salmon ESU, LCR Coho salmon ESU, and LCR Steelhead DPS; however, only steelhead, throughout their range, have more populations above 50 percent of target abundance for recovery than below. Despite habitat improvement work, systemic habitat conditions are still not sufficient to fully support recovery for the four listed LCR species and additional habitat restoration work is still needed, particularly for CR chum, with 14 of 17 populations at less than 10 percent of abundance targets for recovery and only 1 population in each MPG meeting 100 percent of the abundance target. Overall, the risk to all four ESA-listed LCR species persistence from habitat degradation is slightly increasing.

Listing Factor B: Overutilization for commercial, recreational, scientific, or educational purposes

Since the last 5-year review, ocean fisheries management and implementation of selective freshwater fisheries have continued to reduce overall harvest impacts on most of the listed lower Columbia River salmon. The exceptions to this are the fall and bright fall-run components of the LCR Chinook salmon ESU, for which harvest rates have modestly trended upward in recent years (Ford 2022). There remain concerns about both bright fall-run LCR Chinook salmon and LCR coho salmon harvest rate trends and the risk to the species' persistence due to overutilization. The risk to species persistence from scientific research permitting continues to be very low for all four ESA-listed Lower Columbia River species.

The risk to species persistence for LCR Chinook salmon is increasing due to the modest upward trend in incidental harvest impacts on fall and bright fall-run components of the LCR Chinook salmon ESU risk. The risk to species persistence from overutilization has not increased for CR chum, LCR coho, or LCR steelhead.

Listing Factor C: Disease or Predation

The prevalence of disease has not resulted in notable levels of injury or mortality within the last 5-year period, but it is reasonable to assume that warming trends have increased the risk of predation and disease (*C. shasta*) to ESU or DPS viability (Myers, NWFSC, personal communication, December 20, 2021). The disease rates have continued to fluctuate within the range observed in past review periods but may affect the extinction risk of the LCR Chinook salmon ESU, the CR Chum salmon ESU, the LCR Coho salmon ESU and LCR Steelhead DPS. At this time, we do not have information available that would allow us to quantify species-specific impacts of pinniped predation, and avian predation continues to negatively affect juvenile salmon and steelhead survival rates in the LCR. We therefore conclude that the risk to the species' persistence because of disease and predation for LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead has increased slightly since the last 5-year review, but overall remains low to moderate.

Listing Factor D: Inadequacy of Regulatory Mechanisms

Several regulatory mechanisms have resulted in adequate or improved protection since the last 5-year review. Highlights include the State of Washington's Fish Passage Barrier Removal Board establishing a statewide strategy for fish barrier removal and administering grant funding yielding increased tributary access and improved spatial structure across all MPGs, and Oregon Forest Practices Regulations changes yielding wider stream buffers in the context of timber harvest management. This change should lead to improved stream conditions befitting Oregon populations of each MPG; however, additional improvements are still needed to ensure adequate protection of salmon streams on forest lands. Harvest management continues to be regulated primarily through the Pacific Fishery Management Council and the *U.S. v. Oregon* court proceeding. Since the previous 5-year review, a new fisheries management plan was approved by the parties and the court. The 2018-2027 *U.S. v. Oregon Management Agreement* now guides fisheries management in the Columbia River.

Based on the regulatory improvements highlighted above, we conclude that some risk to the species' persistence has slightly decreased. However, there remain concerns regarding continued risk to persistence from other regulatory mechanisms that influence systemic habitat conditions such as water quality, Columbia River mainstem conditions, forest cover, and high head dam passage. Therefore, for all four ESA-listed LCR species, the risk to species persistence is increasing.

Listing Factor E: Other Natural or Manmade Factors affecting Continued Existence

The effects of climate change extend to every habitat and every life history phase of listed LCR salmonids. Effects range from decreasing predictability of annual events such as spring freshets and timing of prey abundance, to increasing stream and ocean temperatures, and setting the stage for increased competition with warm water-adapted nonnative species. These challenges amplify and exacerbate other threats experienced by listed LCR salmonids and are expected to increase in magnitude as climate change progresses.

The level of risk posed to LCR Chinook, CR chum, LCR coho, and LCR steelhead persistence by invasive species displacing or competing with the listed ESUs and DPS has not increased since our 2016 5-year review.

The level of risk posed to LCR Chinook, CR chum, LCR coho, and LCR steelhead persistence by hatcheries has decreased slightly since the 2016 5-year review because of the continuing program changes made over the last five years to reduce hatchery effects on natural-origin populations within the LCR ESUs/DPS.

Taken together, the risk of natural and manmade factors affecting the persistence of the four ESA-listed LCR species existence appears to be increasing because of climate change.

Synthesis

While there have been improvements in the abundance of some populations, we found that the overall viability trends remain low, and well below abundance recovery objectives for LCR Chinook and CR chum. However, LCR coho and LCR steelhead are performing slightly better, with roughly half of their component populations at 50 percent of abundance targets, or greater. Some improvements have been made in listing factors A, B, and D, though A and D have mixed performance with decreases in risk focused on specific populations or for some regulations, while more systemic risks remain or slightly increase. For Listing Factor C, the risk from predation and disease to all four lower Columbia River species remains. For listing Factor B, the risk to three of the four Lower Columbia species decreased since the last review, but risk is increasing for LCR Chinook due to modest upward trend in incidental harvest impacts on fall- and bright fall-run components of the ESU. For Listing Factor E, the risk to all four listed species persistence from climate change is an increasing concern.

Our analysis of the ESA section 4(a)(1) factors indicates that the collective risk to the LCR Chinook salmon ESU, CR Chum ESU, LCR Coho ESU, and LCR Steelhead DPS persistence has not changed significantly since our final listing determination in 2006 and the last 5-year review in 2016. Slight increases in risk in some listing factors are contemporaneous with restoration work and some regulatory improvements, and the recent improvements (particularly habitat restoration work) require time to manifest measurable increases in population viability. Thus, perceived changes in risk do not appear sufficient to warrant changes in any of the four species' status.

Accordingly, when all listing factors and current viability are considered, we conclude that reclassification is not currently warranted for LCR Chinook salmon, CR chum salmon, LCR coho salmon, or LCR steelhead.

2.4.1 ESU/DPS Delineation and Hatchery Membership

Lower Columbia River Chinook Salmon ESU

Delineation

The Northwest Fisheries Science Center's review (Ford 2022) found that no new information had become available that would justify a change in the delineation of the LCR Chinook salmon ESU.

Hatchery Membership

The West Coast Regional Office's 2021 review of new information since the previous 2016 5-year review regarding the LCR Chinook Salmon ESU membership status of various hatchery programs indicates that we have added four hatchery programs to the LCR Chinook Salmon ESU (85 FR 81822, December 17, 2020): Deep River Net Pens-Washougal Program; Klaskanine Hatchery Program; Bonneville Hatchery Program; and the Cathlamet Channel Net Pens Program. We also changed the name of the Sandy River Hatchery Spring Chinook Salmon (ODFW stock #11) program to the Sandy River Hatchery Program to be consistent with other ODFW hatchery programs that have had the "stock #" removed from the listed hatchery program name (85 FR 81822, December 17, 2020).

In addition, the ongoing Hood River Spring Chinook Salmon Program is currently integrating returning natural-origin spring Chinook salmon into the broodstock. The program had been using only spring Chinook salmon returning to the Hood River for broodstock since the release year 2013 when the last release of out-of-basin Deschutes River spring Chinook salmon occurred (NMFS 2018a). Currently the Hood River spring Chinook salmon hatchery broodstock consists solely of spring Chinook salmon returning to the Hood River since the release year 2013 and the program is being managed to encourage local adaptation (i.e., incorporation of natural-origin fish into the broodstock). NMFS intends to continue monitoring the status of the natural-origin population to determine if the Hood River spring Chinook salmon artificially propagated stock is no more divergent relative to the local natural population(s) than what would be expected between closely related natural populations within the ESU (70 FR 37204, June 28, 2005).

Columbia River Chum ESU

Delineation

The Northwest Fisheries Science Center's review (Ford 2022) found that no new information had become available that would justify a change in the delineation of the CR Chum Salmon ESU.

Hatchery Membership

The West Coast Regional Office's 2021 review of new information since the previous 2016 5-year review regarding the CR Chum Salmon ESU membership status of various hatchery programs indicates that we added the Big Creek Hatchery Program because the source for these fish is local natural-origin fish from the Grays River, which is included in the ESU (85 FR 81822, December 17, 2020), and that no further changes in the CR Chum Salmon ESU membership are warranted.

Lower Columbia River Coho Salmon ESU

Delineation

The Northwest Fisheries Science Center's review (Ford 2022) found that no new information had become available that would justify a change in the delineation of the LCR Coho Salmon ESU.

Hatchery Membership

The West Coast Regional Office's 2021 review of new information since the previous 2016 5-year review regarding the LCR Coho Salmon ESU membership status of various hatchery programs indicates that we changed five artificial propagation programs. We added the Clatsop County Fisheries Net Pen Program because the broodstock origin is Tanner Creek, which is included in the ESU. We also added the Clatsop County Fisheries/Klaskanine Hatchery Program because the source for these fish is the Big Creek Hatchery Program, which is included in the ESU. We removed the Kalama River Type-S Coho program because the program was terminated. We also changed the names of four hatchery programs that are currently in the ESU: we removed the ODFW stock numbers from the names of the Big Creek Hatchery Program, Sandy Hatchery Program, and Bonneville/Cascade/Oxbow Complex Hatchery Program; and changed the name of the North Fork Toutle River Hatchery program to the North Fork Toutle River Type-S Hatchery program (85 FR 81822, December 17, 2020).

The West Coast Regional Office's 2021 review of new information since the previous 2016 5-year review revealed that we currently have an ongoing program, the Beaver Creek Hatchery Type-N Coho Program that has two components: an integrated/conservation component and a segregated/harvest component. The integrated component utilizes the Elochoman River's natural-origin later-returning coho salmon for broodstock. The segregated program uses returning hatchery-origin adults from the integrated program for broodstock. The segregated program's goal is to provide harvest opportunities while conserving the natural population and reducing the hatchery program's effects on the ESU. The segregated component releases 700,000 yearlings from the Deep River Net Pens. The integrated component directly releases 225,000 yearlings from the Beaver Creek Hatchery, located on Beaver Creek, a tributary to the Elochoman River (NMFS 2017a).

We also currently have a second ongoing program -- the Deep River Net Pens Coho Program. This program releases coho salmon acclimated in net pens in the Deep River near the mouth of the Grays River to support off-Columbia River mainstem commercial fisheries as part of the SAFE (Select Area Fisheries Evaluation) project (NMFS 2017a). In the past, the program released a mix of Grays River (within the major population group (MPG)) and Lewis River (outside MPG) coho salmon juveniles from the net pens. Under the new Mitchell Act Biological Opinion (NMFS 2017a), the program is transitioning to using only juveniles from the Beaver Creek program described above. The final program is expected to reduce impacts by eliminating the use of juveniles from outside the MPG as well as by reducing the total number released

(NMFS 2017a). This program is similar to the Clatsop County Fisheries Net Pen program that is already included in the ESU (85 FR 81822, December 17, 2020).

Finally, the West Coast Regional Office's 2021 review of new information since the previous 2016 5-year review revealed that we terminated the Fish First Wild Coho Program, with the last release in 2017.

Lower Columbia River Steelhead DPS

Delineation

The 2015 report NWFSC (2015) recommended a revision of the Lower Columbia River steelhead DPS and Upper Willamette River steelhead DPS composition. Specifically, the Clackamas River winter steelhead demographically independent population (DIP), originally included as part of the Lower Columbia River DPS, would be included in the Upper Willamette River DPS. Genetic research published since 2015 further supports the closer affinity of the Clackamas River winter-run steelhead DIP to Upper Willamette River steelhead DPS populations rather than Lower Columbia River steelhead DPS populations (Winans et al. 2018). The NWFSC (2022) believes that the rationale for revising the placement of the Clackamas River winter steelhead DIP originally stated in the NWFSC 2015 report is still accurate and appropriate and does not need further revision.

Hatchery Membership

The West Coast Regional Office's 2021 review of new information since the previous 2016 5-year review regarding the LCR Steelhead DPS membership status of various hatchery programs indicates that we (1) added the recently initiated Upper Cowlitz Wild Program because the source for these fish is local, natural-origin fish from the Upper Cowlitz River, which is included in the DPS; (2) added the recently initiated Tilton River Wild Program because the source for these fish is local, natural-origin fish from the Tilton River; and (3) removed ODFW stock numbers from the names of the Clackamas Hatchery Late Winter-run Program, Sandy Hatchery Late Winter-run Program, and Hood River Winter-run Program (85 FR 81822, December 17, 2020).

The West Coast Regional Office's 2021 review of new information since the previous 2016 5-year review regarding the LCR Steelhead DPS membership status of various hatchery programs also revealed that the Eagle Creek NFH Late Winter Steelhead Program previously reared and released winter steelhead at the Eagle Creek NFH that were a mix of local and out-of-DPS Big Creek Hatchery early winter steelhead. The last release of locally adapted Eagle Creek winter stock took place in 2015; these fish are no longer spawned and are functionally extinct (Peterschmidt, USFWS, personal communication, December 1, 2021). Fish released as part of the Eagle Creek NFH program now come from the Clackamas Hatchery Late Winter Steelhead Program that is currently part of the LCR Steelhead DPS.

2.4.2 ESU/DPS Viability and Statutory Listing Factors

- The Northwest Fisheries Science Center's review of updated information does not indicate a change in the biological risk category for the LCR Chinook Salmon ESU, the CR Chum Salmon ESU, the LCR Coho Salmon ESU, and the LCR Steelhead DPS since the time of their last review (Ford 2022).

- Our analysis of the ESA section 4(a)(1) factors indicates that the collective risk to the persistence of the LCR Chinook Salmon ESU, the CR Chum Salmon ESU, the LCR Coho Salmon ESU, and the LCR Steelhead DPS has not changed significantly since our listing determination in 2006. The overall level of concern remains the same (Ford 2022).

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3. Results

3.1 Classification

3.1.1 LCR Chinook Salmon ESU

Listing status:

Based on the information discussed in the previous sections, we determine that no reclassification for the LCR Chinook salmon ESU is warranted. Therefore, the LCR Chinook salmon ESU should remain listed as threatened.

ESU/DPS Delineation:

The Northwest Fisheries Science Center's review (Ford 2022) found that no new information has become available that would justify a change in the delineation of the LCR Chinook salmon ESU.

LCR Chinook Salmon Hatchery Membership:

For the LCR Chinook salmon ESU, we recommend that the Hood River Spring Chinook Salmon Program continue to be monitored in the near term to determine if it should be considered for inclusion in the ESU for the reasons explained above in previous sections 2.1.1 and 2.4.1.

3.1.2 CR Chum Salmon ESU

Listing status:

Based on the information described in the previous sections, we determine that no reclassification for the CR Chum Salmon ESU is warranted. Therefore, the CR Chum Salmon ESU should remain listed as threatened.

ESU/DPS Delineation:

The Northwest Fisheries Science Center's review (Ford 2022) found that no new information has become available that would justify a change in the delineation of the CR Chum Salmon ESU.

CR Chum Salmon Hatchery Membership:

For the CR Chum Salmon ESU, we do not recommend any changes to the hatchery program membership.

3.1.3 LCR Coho Salmon ESU

Listing status:

Based on the information discussed in the previous sections, we determine that no reclassification for the LCR Coho Salmon ESU is warranted. Therefore, the LCR Coho Salmon ESU should remain listed as threatened.

ESU/DPS Delineation:

The Northwest Fisheries Science Center's review (Ford 2022) found that no new information has become available that would justify a change in the delineation of the LCR Coho Salmon ESU.

LCR Coho Hatchery Membership:

For the LCR Coho Salmon ESU, we recommend:

- Removing the Fish First Wild Coho Program from membership in the ESU because we terminated the Fish First Wild Coho Program, with the last release in 2017.
- Including the Beaver Creek Hatchery Type-N Coho Salmon Program and the Deep River Net Pens Coho Program in the ESU for the reasons explained above in previous sections 2.1.1 and 2.4.1.

3.1.4 LCR Steelhead DPS

Listing status:

Based on the information described previously in this review, we determine that no reclassification for the LCR Steelhead DPS is warranted. Therefore, the LCR Steelhead DPS should remain listed as threatened.

LCR Steelhead ESU/DPS Delineation:

The 2015 report (NWFSC 2015) recommended a revision of the Lower Columbia River Steelhead DPS and Upper Willamette River Steelhead DPS composition. Specifically, we recommend that the Clackamas River winter steelhead demographically independent population (DIP) originally included as part of the Lower Columbia River DPS instead be included in the Upper Willamette River DPS. Genetic research published since 2015 further supports the closer affinity of the Clackamas River winter-run steelhead DIP to Upper Willamette River steelhead DPS populations rather than Lower Columbia River Steelhead DPS populations (Winans et al. 2018). The NWFSC (2022) believes that the rationale for revising the placement of the Clackamas River winter steelhead DIP originally stated in the NWFSC 2015 report is still accurate and appropriate and does not need further review or revision.

While considering whether to adjust the population membership, we will consider additional biological, genetic, and ecological criteria that would assist in making a future determination. If we move forward with this recommendation, related modifications to any associated critical habitat designations, recovery plans, and hatchery programs may be necessary.

LCR steelhead Hatchery Membership:

For the LCR Steelhead DPS, we recommend including the Eagle Creek NFH Winter Steelhead Program in the DPS because fish released as part of the Eagle Creek NFH program now come from the Clackamas Hatchery Late Winter Steelhead Program that is currently included in the LCR Steelhead DPS.

3.2 New Recovery Priority Numbers

Since the previous 2016 5-year review, NMFS revised the recovery priority number guidelines and twice evaluated the numbers (NMFS 2019a, NMFS 2022). Table 4 indicates the numbers in place at the beginning of the current review. In January 2022, the number remained 3C for the LCR Chinook Salmon ESU, CR Chum Salmon ESU, and LCR Steelhead DPS, but was revised from 4C to 3C for the LCR Coho Salmon ESU.

As part of this 5-year review we reevaluated the numbers based on the best available information, including the new viability assessment (Ford 2022), and concluded that the current recovery priority number for all four species remains 3C.

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4. Recommendations for Future Actions

In our review of the listing factors and the Northwest Fisheries Science Center's biological viability assessment, we identified many recommended actions to improve factors influencing the status of the ESUs and DPS. Here we present those actions that provide the greatest opportunity to improve the VSP parameters, and advance the recovery of LCR Chinook salmon, CR chum salmon, LCR coho salmon, and LCR steelhead. Specifically, we recommend the following actions:

For all populations and all MPGs that comprise the four listed species in the Lower Columbia River – CR chum salmon, LCR Chinook salmon, LCR steelhead, and LCR coho salmon recommended future recovery actions over the next five years include:

- Conduct systematic review and analysis of high priority Lower Columbia River mainstem and tributary area habitat needs, identified in NMFS 2013a, and compare needs to what has been accomplished.
- Conduct monitoring to evaluate ship wake stranding frequency and locations where stranding occurs and assess factors contributing to wake stranding such as location, topography, vessel speed, et cetera, to determine best practices to reduce wake stranding mortality.
- Promote riparian plantings of native canopy tree cover species opportunistically in all watersheds.
- Coordinate with EPA in an evaluation of Washington State Water Quality Standards, reflecting Oregon and Idaho consultation outcomes.
- Increase the number of habitat projects that target fall Chinook salmon spawning (Big Creek, Elochoman/Skamokawa, Clatskanie River, Mill/Abernathy/Germany Creek, Toutle River, and Hood River).
- Apply results from the Lower Columbia Intensively Monitored Watershed study of Mill, Abernathy, and Germany creeks – a Before After Control Impact Design study which assessed how restoration influenced salmon and steelhead abundance (WDFW 2012) – to future restoration efforts targeting coho salmon, to improve habitat restoration methods across all MPGs and promote abundance of this species.

For populations within the below listed MPGs, we recommend the following recovery actions over the next five years:

<u>Coast MPGs</u>

- Increase the number of projects that reduce sediment load in spawning habitat for Grays/Chinook River chum,

- Implement projects that increase the amount of side channel/pool rearing habitat for Grays/Chinook River coho.

- Promote projects that reduce flashy stream conditions to improve spawning habitat for Grays/Chinook River chum, Grays/Chinook River fall Chinook salmon, and Grays/Chinook River coho.

- Implement projects to increase summer and winter rearing habitat complexity for Mill/Abernathy/Germany Creek coho.

- Implement additional habitat improvement projects in the Elochoman River and Abernathy, Mill, and Germany creeks, and their tributaries to augment spawning (chum) and rearing (coho) habitat.

Cascade MPGs

- Reestablish and improve passage on multiple rivers to benefit multiple populations from the Cascade MPGs, such as the North Fork Lewis River (NF Lewis River spring Chinook, NF Lewis River winter steelhead, NF Lewis River coho), and Cowlitz River (Upper Cowlitz River spring Chinook, Upper Cowlitz River fall Chinook, Upper Cowlitz River coho, Upper Cowlitz River winter steelhead).
- Identify and implement spawning habitat projects to expand spatial distribution of chum into the Cascade MPG, with priority on the Lewis and Washougal rivers, (Washington Primary populations) and the Cowlitz and Kalama rivers (contributing populations).

- Work with county and city jurisdictions to protect watershed hydrology from long-term development impacts (floodplain development and groundwater withdrawals). Focus these efforts on high growth rate watersheds along the I-5 and I-205 corridors, including the East Fork Lewis River, North Fork Lewis River, Coweeman River, Kalama River, Washougal River, Salmon Creek, and Lower Cowlitz tributaries.

Gorge MPGs

- Continue to work with partners on programs protecting instream and floodplain habitats in key chum spawning areas, such as Duncan Creek and Hamilton Creek, (e.g., evaluate if large wood debris mitigates excess winter stream flows that degrade spawning for Upper Gorge chum).

- Continue to work with partners to identify suitable chum spawning habitat streams and reaches to emplace habitat creation or enhancement projects in order to expand spatial distribution into the gorge strata.

- Improve understanding of key factors limiting recovery by evaluating summer-run Gorge steelhead losses between Bonneville Dam and Shipherd Falls.

- Implement the EPA 2021 Columbia River Cold Water Refuges Plan, for example in Woodard Creek, to benefit Upper Gorge (Wind River and White Salmon rivers) LCR fall Chinook salmon, Lower Gorge (Woodard Creek) winter steelhead, Upper Gorge (Wind River) steelhead, and Wind River summer steelhead.

- Implement habitat projects to mitigate excess winter flow to improve spawning habitat for Lower Gorge chum and Upper Gorge chum.

- Increase channel complexity to improve juvenile rearing habitat for Wind River summer steelhead.

- Pacific salmon and steelhead recovery partners are encouraged to develop and implement a long-term management strategy to reduce pinniped predation on Pacific salmon and steelhead in the Columbia River basin by removing, reducing, and-or minimizing the use of manmade haul outs used by pinnipeds in select areas (e.g., river mouths/migratory pinch points).

- Pacific salmon and steelhead recovery partners are encouraged to expand, develop, and implement monitoring efforts in the Columbia River basin, to identify pinniped predation interactions in select areas (e.g., river mouths/migratory pinch points) and quantitatively assess predation impacts by pinnipeds on Pacific salmon and steelhead stocks.

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5. References

5.1 Federal Register Notices

November 20, 1991 (56 FR 58612). Notice of Policy: Policy on Applying the Definition of Species Under the Endangered Species Act to Pacific Salmon.

February 7, 1996 (61 FR 4722). Notice of Policy: Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act.

March 19, 1998 (63 FR 13347). Final Rule: Endangered and Threatened Species: Threatened Status for Two ESUs of Steelhead in Washington, Oregon, and California.

March 24, 1999 (64 FR 14308). Final Rule: Endangered and Threatened Species: Threatened Status for Three Chinook Salmon Evolutionarily Significant Units (ESUs) in Washington and Oregon, and Endangered Status for One Chinook Salmon ESU in Washington.

March 25, 1999 (64 FR 14508). Final Rule: Endangered and Threatened Species: Threatened Status for Two ESUs of Chum Salmon in Washington and Oregon.

September 16, 1999 (64 FR 50394). Final Rule; Notice of Determination: Endangered and Threatened Species; Threatened Status for Two Chinook Salmon Evolutionarily Significant Units (ESUs) in California.

July 10, 2000 (65 FR 42421). Final Rule: Endangered and Threatened Species; Final Rule Governing Take of 14 Threatened Salmon and Steelhead Evolutionarily Significant Units (ESUs).

June 28, 2005 (70 FR 37159). Final Rule: Endangered and Threatened Species: Final Listing Determinations for 16 ESUs of West Coast Salmon, and Final 4(d) Protective Regulations for Threatened Salmonid ESUs.

June 28, 2005 (70 FR 37204). Final Policy: Policy on the Consideration of Hatchery-Origin Fish in Endangered Species Act Listing Determinations for Pacific Salmon and Steelhead.

September 2, 2005 (70 FR 52630). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for 12 Evolutionarily Significant Units of West Coast Salmon and Steelhead in Washington, Oregon, and Idaho.

January 5, 2006 (71 FR 834). Final Rule: Endangered and Threatened Species: Final Listing Determinations for 10 Distinct Population Segments of West Coast Steelhead.

July 10, 2000 (65 FR 42450). Final Rule: Endangered and Threatened Species; Final Rule Governing Take of 14 Threatened Salmon and Steelhead Evolutionarily Significant Units (ESUs).

August 15, 2011 (76 FR 50448). Notice of availability of 5-year reviews: Endangered and Threatened Species; 5-Year Reviews for 17 Evolutionarily Significant Units and Distinct Population Segments of Pacific Salmon and Steelhead.

July 12, 2013 (78 FR 41911). Notice of availability: Endangered and Threatened Species; Recovery Plans.

February 24, 2016 (81 FR 9252). Final Rule: Endangered and Threatened Species; Designation of Critical Habitat for Lower Columbia River Coho Salmon and Puget Sound Steelhead.

May 26, 2016 (81 FR 33468). Notice of Availability of 5-year Reviews Endangered and Threatened Species; 5-Year Reviews for 28 Listed Species of Pacific Salmon, Steelhead, and Eulachon.

April 30, 2019 (84 FR 18243). Notice of Final Guidelines: Endangered and Threatened Species; Listing and Recovery Priority Guidelines.

October 4, 2019 (84 FR 53117). Notice of Initiation of 5-year Reviews: Endangered and Threatened Species; Initiation of 5-Year Reviews for 28 Listed Species of Pacific Salmon and Steelhead.

December 17, 2020 (85 FR 81822). Final Rule: Revisions to Hatchery Programs Included as Part of Pacific Salmon and Steelhead Species Listed Under the Endangered Species Act.

August 2, 2021 (86 FR 41668). Final Rule: Revision of Critical Habitat for the Southern Resident Killer Whale Distinct Population Segment.

September 14, 2020 (85 FR 57298). Notice of Proposed Rulemaking: Proposal to Reissue and Modify Nationwide Permits.

5.2 Personal Communications

Karnezis, J. 2019. Communication to L. Krasnow (NMFS) from J. Karnezis (BPA), 12/19/2019.

LCFRB. 2020. Personal communication from Lower Columbia Fish Recovery Board, received 11/13/2020.

Manlow, S. 2021. Email communication Aug 10, 2021 from Steve Manlow, Executive Director of LCFRB.

Myers, J. 2021. Communication to Nora Berwick, Rob Markle, Diana Dishman from Jim Myers, NWFSC.

Myers, J. 2022. Personal communication regarding moderate to high viability risk level for Columbia River chum from Jim Myers, NWFSC. May 11, 2022.

Peterschmidt, C. 2021. USFWS Eagle Creek National Fish Hatchery Manager. Personal communication regarding history of steelhead stock released at Eagle Creek National Fish Hatchery. December 1, 2021.

5.3 Literature Cited

Agee, J.K. 1996. Fire ecology of Pacific Northwest forests, 505 p. Island Press, Washington, D.C..

Agne, M.C., P.A. Beedlow, D.C. Shaw, D.R. Woodruff, E.H. Lee, S.P. Cline, R.L. Comeleo. 2018. Interactions of predominant insects and diseases with climate change in Douglas-fir forests of western Oregon and Washington, USA. Forest Ecology and Management 409:317-332.

Antolos, M., D.D. Roby, D.E. Lyons, K. Collis, A.F. Evans, M. Hawbecker, and B.A. Ryan. 2005. Caspian tern predation on juvenile salmonids in the Mid-Columbia River. Transactions of the American Fisheries Society. 134(2):466-480.

Beechie, T., E. Buhle, M. Ruckelshaus, A. Fullerton, and L. Holsinger. 2006. Hydrologic regime and the conservation of salmon life history diversity. Biological Conservation. 130:560-572.

Black, B.A., P. van der Sleen, E. Di Lorenzo, D. Griffin, W.J. Sydeman, J.B. Dunham, R.R. Rykaczewski, M. Garcia-Reyes, M. Safeeq, I. Arismendi, and S.J. Bograd. 2018. Rising synchrony controls western North American ecosystems. Global Change Biology. 24(6):2305-2314.

Bottom, D.L., C.A. Simenstad, J. Burke, A.M. Baptista, D.A. Jay, K.K. Jones, E. Casillas, and M.H. Schiewe. 2005. Salmon at River's End: The Role of the Estuary in Decline and Recovery of Columbia River Salmon. U.S. Dept. Commerce, NOAA Technical Memorandum. NMFS-NWFSC-68. 246 p.

BPA (Bonneville Power Administration), USBR (U.S. Bureau of Reclamation), and USACE (U.S. Army Corps of Engineers). 2020. Biological Assessment of Effects of the Operations and Maintenance of the Federal Columbia River System on ESA-Listed Species. Bonneville Power Administration, Portland, Oregon, January 1, 2020.

Breyta R., I. Brito, G. Kurath, S. LaDeau. 2017. Infectious hematopoietic necrosis virus virological and genetic surveillance 2000–2012. Ecology. 98:283. https://doi.org/10.1002/ecy.1634.

Carretta, J.V., Forney, K.A., Oleson, E.M., Weller, D.W., Lang, A.R., Baker, J., Muto, M.M., Hanson, B., Orr, A.J., Huber, H., Lowry, M.S., Barlow, J., Moore, J.E., Lynch, D., Carswell, L., and Brownell Jr., R.L. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-SWFSC-617. June 1, 2019.

Carr-Harris, C. N., J. W Moore, A.S. Gottesfeld, J.A. Gordon, W.M. Shepert, J.D.J. Henry Jr., H.J. Russell, W.N.B. Helin, D.J. Doolan, and T.D. Beacham. 2018. Phenological diversity of salmon smolt migration timing within a large watershed. Transactions of the American Fisheries Society. 147(5):775-790.

Center for Whale Research. 2021. Website. https://www.whaleresearch.com/orca-population; accessed November 19, 2021.

Clark, S.M., J.B. Dunham, J.R. McEnroe, and S.W. Lightcap. 2014. Breeding site selection by coho salmon (*Oncorhynchus kisutch*) in relation to large wood additions and factors that influence reproductive success. Canadian Journal of Fisheries and Aquatic Sciences. 71:1498-1507.

Chasco, B.E., I.C. Kaplan, A.C. Thomas, A. Acevedo-Gutiérrez, D.P. Noren, M.J. Ford, M.B. Hanson, J.J. Scordino, S.J. Jeffries, K.N. Marshall, A.O. Shelton, C. Matkin, B.J. Burke, and E.J. Ward. 2017. Competing tradeoffs between increasing marine mammal predation and fisheries harvest of Chinook salmon. Scientific Reports. 7:15439

Collis, K., D.D. Roby, D.P. Craig, B.A. Ryan, and R.D. Ledgerwood. 2001. Colonial waterbird predation on juvenile salmonids tagged with passive integrated transponders in the Columbia River Estuary: vulnerability of different salmonid species, stocks, and rearing types. Transactions of the American Fisheries Society. 130:385-396.

Collis, K., D.D. Roby, D.P. Craig, S. Adamany, J.Y. Adkins, and D.E. Lyons. 2002. Colony size and diet composition of piscivorous waterbirds on the Lower Columbia River: implications for loses of juvenile salmonids to avian predation. Transactions of the American Fisheries Society. 131:537-550.

Collis, K., D.D. Roby, D.E. Lyons, Y. Suzuki, J.Y. Adkins, L. Reinalda, N. Hostetter, L. Adrean, M. Bockes, P. Loschl, D. Battaglia, T. Marcella, B. Cramer, A. Evans, M. Hawbecker, M. Carper, J. Sheggeby, and S. Sebring. 2009. Research, monitoring, and evaluation of avian predation on salmonid smolts in the lower and mid-Columbia River. 2008 final season summary. Prepared for the Bonneville Power Administration and the U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

Cooper, M.G., J.R. Schaperow, S.W. Cooley, S. Alam, L.C. Smith, and D.P. Lettenmaier. 2018. Climate elasticity of low flows in the maritime western U.S. Mountains. Water Resources Research. 54(8):5602–5619. https://doi.org/10.1029/2018WR022816

Crozier, L.G., and R.W. Zabel. 2006. Climate impacts at multiple scales: evidence for differential population responses in juvenile Chinook salmon. Journal of Animal Ecology. 75:1100-1109.

Crozier, L., R.W. Zabel, S. Achord, and E.E. Hockersmith. 2010. Interacting effects of density and temperature on body size in multiple populations of Chinook salmon. Journal of Animal Ecology. 79:342-349.

Crozier L.G., M.M. McClure, T. Beechie, S.J. Bograd, D.A. Boughton, M. Carr, T. D. Cooney, J.B. Dunham, C.M. Greene, M.A. Haltuch, E.L. Hazen, D.M. Holzer, D.D. Huff, R.C. Johnson, C.E. Jordan, I.C. Kaplan, S.T. Lindley, N.Z. Mantua, P.B. Moyle, J.M. Myers, M.W. Nelson, B.C. Spence, L.A. Weitkamp, T.H. Williams, and E. Willis-Norton. 2019. Climate vulnerability assessment for Pacific salmon and steelhead in the California Current Large Marine Ecosystem. PLoS ONE 14(7): e0217711. https://doi.org/10.1371/journal.pone.0217711

Daly, E.A., and R.D. Brodeur. 2015. Warming ocean conditions relate to increased trophic requirement of threatened and endangered salmon. PLoS ONE 10:e0144066.

Dorner, B., M.J. Catalano, and R.M. Peterman. 2018. Spatial and temporal patterns of covariation in productivity of Chinook salmon populations of the northeastern Pacific Ocean. Canadian Journal of Fisheries and Aquatic Sciences 75(7):1082-1095.

Ebersole, J.L., M.E. Colvin, P.J. Wigington Jr, S.W. Lightcap, J.P. Baker, M.R. Church, J.E. Compton, and M.A. Cairns. 2009. Hierarchical modeling of late summer weight and summer abundance of juvenile coho salmon across a stream network. Transactions of the American Fisheries Society. 138:1138-1156.

Evans, A.F., N.J. Hostetter, D.D. Roby, K. Collis, D.E. Lyons, B.P. Sandford, R.D. Ledgerwood, and S. Sebring. 2012. Systemwide evaluation of avian predation on juvenile salmonids from the Columbia River based on recoveries of passive integrated transponder tags. Transactions of the American Fisheries Society. 141(4):975-989.

Evans, A., Q. Payton, B. Cramer, K. Collis, N.J. Hostetter, and D.D. Roby. 2019. System-wide effects of avian predation on the survival of Upper Columbia River steelhead: Implications for predator management. Draft Report submitted to Grant County Public Utility District No. 2 and the Priest Rapids Coordinating Committee. Final Report.

Erhardt, J.M., and K.F. Tiffan. 2018. Post-release predation mortality of age-0 hatchery-reared Chinook salmon from non-native smallmouth bass in the Snake River. Fisheries Management and Ecology. 25:474– 487. https://doi.org/10.1111/fme.12322

Erhardt, J.M., K.F. Tiffan, and W.P. Connor. 2018. Juvenile Chinook salmon mortality in a Snake River reservoir: smallmouth bass predation revisited. Transactions of the American Fisheries Society. 147:316-328. https://doi.org/10.1002/tafs.10026

EPA. 2020. News Release from Regions 08 and 10: EPA awards $2 million in grants to reduce toxics throughout Columbia River Basin. Sept 16, 2020. https://www.epa.gov/newsreleases/epa-awards-2-million-grants-reduce-toxics-throughout-columbia-river-basin.

Ford, J.K. and G.M. Ellis. 2006. Selective foraging by fish-eating killer whales *Orcinus orca* in British Columbia. Marine Ecology Progress Series. 316:185-199.

Ford, M.J. (Ed.), T. Cooney, P. McElhany, N. Sands, L. Weitkamp, J. Hard, M. McClure, R. Kope, J. Myers, A. Albaugh, K. Barnas, D. Teel, P. Moran, and J. Cowen. 2011. Status review update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce. NOAA Technical Memorandum NMFS-NWFSC-113. November 2011.

Ford, M.J., J. Hempelmann, M.B. Hanson, K.L. Ayres, R.W. Baird, C.K. Emmons, J.I. Lundin, G.S. Schorr, S.K. Wasser, and L.K. Park. 2016. Estimation of a killer whale (*Orcinus orca*) population's diet using sequencing analysis of DNA from feces. *PLoS ONE*, 11(1), p.e0144956.

Ford, M.J., editor. 2022. Biological viability assessment update for Pacific salmon and steelhead listed under the Endangered Species Act: Pacific Northwest. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-NWFSC-171. https://doi.org/10.25923/kq2n-ke70

Fresh, K.L., L.L. Casillas, L.L. Johnson, and D.L. Bottom. 2005. Role of the estuary in the recovery of Columbia River basin salmon and steelhead: an evaluation of the effects of selected factors on salmonid population viability. U.S. Dep. Commerce NOAA Tech. Memo. NMFS-NWFSC-69.

Friesen, T.A., and D.L. Ward. 1999. Management of Northern pikeminnow and implications for juvenile salmonid survival in the lower Columbia and Snake rivers. North American Journal of Fisheries Management. 19:406–420.

Fuhrman, A.E., D.A. Larsen, E.A. Steel, G. Young, and B.R. Beckman. 2018. Chinook salmon emergence phenotypes: describing the relationships between temperature, emergence timing and condition factor in a reaction norm framework. Ecology and Freshwater Fish. 27:350-362.

GAO (U.S. Government Accountability Office) 2018. Columbia River Basin: Additional federal actions would benefit restoration efforts. GAO-18-561. August 2018.

Gliwicz, Z.M., E. Babkiewicz, R. Kumar, S. Kunjiappan, and K. Leniowski. 2018. Warming increases the number of apparent prey in reaction field volume of zooplanktivorous fish. Limnology and Oceanography. 63:S30-S43.

Good, T.P., R.S. Waples, and P. Adams (Editors). 2005. Updated status of federally listed ESUs of West Coast salmon and steelhead. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-66, 598 p.

Gourtay, C., D Chabot, C. Audet, H. Le Delliou, P. Quazuguel, G. Claireaux, and J-L Zambonino-Infante. 2018. Will global warming affect the functional need for essential fatty acids in juvenile sea bass (*Dicentrarchus labrax*)? A first overview of the consequences of lower availability of nutritional fatty acids on growth performance. Marine Biology. 9:165:143.

Halofsky, J.E., D.L. Peterson, and H.R. Prendeville. 2018a. Assessing vulnerabilities and adapting to climate change in northwestern US forests. Climatic Change 146(1-2):89-102.

Halofsky, J.S., D.R. Conklin, D.C. Donato, J.E. Halofsky, and J.B. Kim. 2018b. Climate change, wildfire, and vegetation shifts in a high-inertia forest landscape: Western Washington, USA. PLoS ONE 13(12):e0209490.

Hanson, M.B., R.W. Baird, J.K. Ford, J. Hempelmann-Halos, D.M.Van Doornik, J.R. Candy, C.K. Emmons, G.S. Schorr, B. Gisborne, K.L. Ayres, and S.K. Wasser. 2010. Species and stock identification of prey consumed by endangered southern resident killer whales in their summer range. Endangered Species Research. 11(1):69-82.

Hanson, B., M., Emmons, C.K., Ward, E.J., Nystuen, J.A. and Lammers, M.O. 2013. Assessing the coastal occurrence of endangered killer whales using autonomous passive acoustic recorders. The Journal of the Acoustical Society of America. 134(5):3486-3495.

Hanson, M.B., C.K. Emmons, M.J. Ford, M. Everett, K. Parsons, L.K. Park, J. Hempelmann, D.M. Van Doornik, G.S. Schorr, J.K. Jacobsen, and M.F. Sears. 2021. Endangered predators and endangered prey: seasonal diet of Southern Resident killer whales. PLoS ONE. 16(3):e0247031.

Haskell, C.A., D.A. Beauchamp, S.M. Bollens. (2017) Linking functional response and bioenergetics to estimate juvenile salmon growth in a reservoir food web. PLoS ONE. 12(10):e0185933. https://doi.org/10.1371/journal.pone.0185933

Haskell, C.A. 2018. From salmon to shad: Shifting sources of marine-derived nutrients in the Columbia River Basin. Ecology and Freshwater Fish. 27:310-322. https://doi.org/10.1111/eff.12348

Hawkins, B.L., A.H. Fullerton, B.L. Sanderson, and E.A. Steel. 2020. Individual-based simulations suggest mixed impacts of warmer temperatures and a nonnative predator on

Chinook salmon. Ecosphere. 11(8):e03218. https://doi.org/10.1002/ecs2.3218

Healey, M. 2011. The cumulative impacts of climate change on Fraser River sockeye salmon (*Oncorhynchus nerka*) and implications for management. Canadian Journal of Fisheries and Aquatic Sciences. 68:718-737.

Healy, T. M., R. S. Brennan, A. Whitehead, and P. M. Schulte. 2018. Tolerance traits related to climate change resilience are independent and polygenic. Global Change Biology. 24(11):5348-5360.

Hernandez, D.G., W. Brown, K.A. Naish, and G. Kurath. 2021. Virulence and infectivity of UC, MD, and L Strains of infectious hematopoietic necrosis virus (IHNV) in four populations of Columbia River Basin Chinook salmon. Viruses. 13(4):701. Published online April 18, 2021. https://doi.org/10.3390/v13040701

Herring, S.C., N. Christidis, A. Hoell, M.P. Hoerling, and P.A. Stott, eds. 2018. Explaining extreme events of 2016 from a climate perspective. Bulletin of the American Meteorological Society. 99(1):S1-S157.

Holden, Z.A., A. Swanson, C.H. Lucec, W.M. Jollyd, M. Manetae, J.W. Oylerf, D.A. Warren, R. Parsons, and D. Affleck. 2018. Decreasing fire season precipitation increased recent western US forest wildfire activity. Proceedings of the National Academy of Sciences of the United States of America. 115(36):E8349-E8357.

Hostetter, N.J., A.F. Evans, Q. Payton, D.D. Roby, D.E. Lyons, and K. Collis. 2021. Chapter 10: Factors affecting the susceptibility of juvenile salmonids to avian predation in D.D. Roby, A.F. Evans, and K. Collis (editors). Avian Predation on Salmonids in the Columbia River Basin: A Synopsis of Ecology and Management. A synthesis report submitted to the U.S Army Corps of Engineers, Walla Walla, Washington; the Bonneville Power Administration, Portland, Oregon; the Grant County Public Utility District/Priest Rapids Coordinating Committee, Ephrata, Washington; and the Oregon Department of Fish and Wildlife. Salem, Oregon. 788 pp.

Hostetter, N.J., A.F. Evans, D.D. Roby, and K. Collis. 2012. Susceptibility of juvenile steelhead to avian predation: the influence of individual fish characteristics and river conditions. Transactions of the American Fisheries Society. 141(6):1586-1599.

IPCC (Intergovernmental Panel on Climate Change). 2018. IPCC SR15: Summary for Policymakers, in IPCC Special Report Global Warming of 1.5°C. Allen, M., Babiker, M., Chen, Y. and de Coninck, H.C. https://research.tue.nl/nl/publications/2439b00f-8f49-49e9-b3c0-68e53d7f261c

Isaak, D.J., C.H. Luce, D.L. Horan, G.L. Chandler, S.P. Wollrab, and D.E. Nagel. 2018. Global warming of salmon and trout rivers in the northwestern U.S.: Road to ruin or path through purgatory? Transactions of the American Fisheries Society. 147(3):566-587.

ISAB (Independent Scientific Advisory Board for the Northwest Power and Conservation Council). 2011. Columbia River Food Webs: Developing a Broader Scientific Foundation for Fish and Wildlife Restoration. ISAB Report 2011-1, Portland, Oregon. January 7, 2011.

ISAB (Independent Scientific Advisory Board for the Northwest Power and Conservation Council). 2015. Density Dependence and its Implications for Fish Management and Restoration Programs in the Columbia River Basin. ISAB 2015-1. February 25, 2015. Portland, Oregon.

Jacox, M.G., M.A. Alexander, N.J. Mantua, J.D. Scott, G. Hervieux, R.S. Webb, and F.E. Werner. 2018. Forcing of multiyear extreme ocean temperature that impacted California Current living marine resources in 2016. Bulletin of the American Meteorological Society. 99(1):S27-S33.

Johnson, O.W., T.A. Flagg, D.J. Maynard, G.B. Milner, and F.W. Waknitz. 1991. Status review for lower Columbia River coho salmon. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-F/NWC-202.

Johnson, O.W., W.S. Grant, R.G. Kope, K.G. Neely, F.W. Waknitz, and R.S. Waples. 1997. Status review of chum salmon from Washington, Idaho, Oregon, and California. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-32.

Johnson, B.M., B.M. Kemp, and G.H. Thorgaard. 2018. Increased mitochondrial DNA diversity in ancient Columbia River basin Chinook salmon *Oncorhynchus tshawytscha*. PLoS ONE. 13(1):e0190059.

Johnston, J.D., C.J. Dunn, M.J. Vernon, J.D. Bailey, B.A. Morrissette, and K.E. 2018. Restoring historical forest conditions in a diverse inland Pacific Northwest landscape. Ecosphere. 9(8):e02400.

Keefer, M.L., C.A. Peery, and C.C. Caudill. 2008. Migration timing of Columbia River spring Chinook salmon: effects of temperature, river discharge, and ocean environment. Transactions of the American Fisheries Society. 137:1120-1133.

Keefer, M.L., T.S. Clabough, M.A. Jepson, E.L. Johnson, C.A. Peery, and C.C. Caudill. 2018. Thermal exposure of adult Chinook salmon and steelhead: Diverse behavioral strategies in a large and warming river system. PLoS ONE. 13:e0204274.

Kidd, S.A., M.D. Schwartz, R.N. Fuller, R. McNatt, K. Poppe, T.D. Peterson, J.A. Needoba, L.P. Cook, J. Cordell, M. Ramirez, A.C. Hanson, A.B. Borde, S.A. Zimmerman. S.A. Hinton, J. Grote, P.M. Chittaro, D. Kuligowski, G.M. Ylitalo, D. Lomax, V.I. Cullinan., L. Johnson, and C.A. Corbett. 2019. Lower Columbia River ecosystem monitoring program, annual report for year 14 (October 1, 2017 to September 30, 2018). Prepared by the Lower Columbia Estuary Partnership for the Bonneville Power Administration. April 2019.

Krosby, M., D.M. Theobald, R. Norheim, and B.H. McRae. 2018. Identifying riparian climate corridors to inform climate adaptation planning. PLoS ONE. 13(11):e0205156.

Kurath, G. 2012. An online database for IHN virus in Pacific Salmonid fish-MEAP-IHNV: U.S. Geological Survey Fact Sheet. 3027:4 p.

Lahnsteiner, F., and M. Kletzl. 2012. The effect of water temperature on gamete maturation and gamete quality in the European grayling (*Thymalus thymallus*) based on experimental data and on data from wild populations. Fish Physiology. 38:455-467.

Lawes, T.J., K.S. Bixler, D.D. Roby, D.E. Lyons, K. Collis, A.F. Evans, A. Peck-Richardson, B. Cramer, Y. Suzuki, J.Y. Adkins, K. Courtot, and Q. Payton. 2021. Chapter 4: Double-crested cormorant management in the Columbia River estuary in D. D. Roby, A. F. Evans, and K. Collis (editors). Avian Predation on Salmonids in the Columbia River Basin: A Synopsis of Ecology and Management. A synthesis report submitted to the U.S. Army Corps of Engineers, Walla Walla, Washington; the Bonneville Power Administration, Portland, Oregon; the Grant County Public Utility District/Priest Rapids Coordinating Committee, Ephrata, Washington; and the Oregon Department of Fish and Wildlife. Salem, Oregon. 788 pp.

Lawrence, D.J., J.D. Olden, and C.E. Torgensen. 2012. Spatiotemporal patterns and habitat associations of smallmouth bass (*Micropterus dolomieu*) invading salmon-rearing habitat. Freshwater Biology. 57:1929-1946. https://doi.org/10.1111/j.1365-2427.2012.02847.x

LCEP (Lower Columbia Estuary Partnership). 2020. Steigerwald Reconnection Project. Retrieved October 2, 2020 from: https://www.estuarypartnership.org/our-work/habitat-restoration/steigerwald-floodplain-restoration-project.

LCFRB (Lower Columbia Fish Recovery Board). 2004. Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. Lower Columbia Fish Recovery Board, Olympia, WA.

LCFRB (Lower Columbia Fish Recovery Board). 2010. Washington Lower Columbia Salmon Recovery and Fish & Wildlife Subbasin Plan. May 28, 2010. Lower Columbia Fish Recovery Board, Longview, Washington. 788p.

LCFRB. 2020a. (Lower Columbia Fish Recovery Board). Salmon habitat project data. Retrieved September 30 – October 22, 2020, from https://srp.rco.wa.gov/

LCFRB. 2020b. (Lower Columbia Fish Recovery Board). Salmon habitat project data. Retrieved November 12, 2020, from https://www.lowercolumbiasalmonrecovery.org/projects/projectlist#b

Lyons, D.E., A.F. Evans, N.J. Hostetter, A. Piggott, L. Weitkamp, T. Good, D.D. Roby, K. Collis, P. Loschl, and B. Cramer. 2014. Factors influencing predation on juvenile salmonids by double-crested cormorants in the Columbia River estuary: a retrospective analysis. Report to the U.S. Army Corps of Engineers. February 17, 2014.

Malek, K., J.C. Adam, C.O. Stockle, and R.T. Peters. 2018b. Climate change reduces water availability for agriculture by decreasing non-evaporative irrigation losses. Journal of Hydrology. 561:444-460.

Maher, M., M.B. Sheer, E.A. Steel, and P. McElhany. 2005. Atlas of Salmon and Steelhead Habitat in the Oregon Lower Columbia and Willamette Basins. Report for the Willamette-Lower Columbia Technical Recovery Team. Produced by the NOAA Northwest Fisheries Science Center. 203 p.

Marcoe, K. and S. Pilson. 2017. Habitat change in the lower Columbia River estuary, 1870-2009. Journal of Coastal Conservation. 21:505-525. https://doi.org/10.1007/s11852-017-0523-7.

Marshall, K.N., A.C. Stier, J.F. Samhouri, R.P. Kelly, and E.J. Ward. 2016. Conservation challenges of predator recovery. Conservation Letters. 9(1):70-78.

McCullough, D., S. Spalding, D. Sturdevant, and M. Hicks. 2001. Issue Paper 5. Summary of technical literature examining the physiological effects of temperature. Region 10 temperature water quality criteria guidance development project. U.S. Environmental Protection Agency. EPA-910-D-01-005, May 2001.

McElhany, P., M. Ruckleshaus, M.J. Ford, T. Wainwright, and E. Bjorkstedt. 2000. Viable Salmon Populations and the Recovery of Evolutionarily Significant Units. U. S. Department of Commerce, National Marine Fisheries Service, Northwest Fisheries Science Center, NOAA Technical Memorandum NMFS-NWFSC-42. 156 p. https://www.nwfsc.noaa.gov/assets/25/6190_06162004_143739_tm42.pdf.

McElhany, P., M. Chilcote, J. Myers, and R. Beamesderfer. 2007. Viability Status of Oregon Salmon and Steelhead Populations in the Willamette and Lower Columbia Basins. Report Prepared for Oregon Department of Fish and Wildlife and National Marine Fisheries Service.

Metro. 2014. 2014 Urban Growth Report: Investing in our communities 2015-2035. Metro. 30 p.

Moore, M.E., Berejikian, B.A., Greene, C.M. and Munsch, S., 2021. Environmental fluctuation and shifting predation pressure contribute to substantial variation in early marine survival of steelhead. Marine Ecology Progress Series. 662:139-156.

Morace, J.L. 2012. Reconnaissance of contaminants in selected wastewater-treatment-plant effluent and stormwater runoff entering the Columbia River, Columbia River Basin, Washington and Oregon, 2008–10: U.S. Geological Survey Scientific Investigations Report 2012–5068, 68 p.

Muto, M.M., V.T. Helker, B.J. Delean, N.C. Young, J.C. Freed, R.P. Angliss, B.A. Allen, P.L. Boveng, J.M. Breiwick, B.M. Brost, M.F. Cameron, P.J. Clapham, J.L. Crance, S.P. Dahle, M.E. Dahleim, B.S. Fadely, M.C. Ferguson, L.W. Fritz, K.T. Goetz, R.C. Hobbs, Y.V. Ivashchenko, A.S. Kennedy, J.M. London, S.A. Mizroch, R.R. Ream, E.L. Richmond, K.E.W. Shelden, K.L. Sweeny, R.G. Towell, P.R. Wade, J.M. Waite, and A.N. Zerbini. 2021. Alaska Marine Mammal Stock Assessments, 2020. NOAA Technical Memorandum NMFS-AFSC-421.

Myers, J., C. Busack, D. Rawding, A. Marshall, D. Teel, D.M. Van Doornik and M.T. Maher. 2006. Historical Population Structure of Pacific Salmonids in the Willamette River and Lower Columbia River Basins. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS-NWFSC-73. 311 p.

Naiman, R.J., C.A. Johnston, and J.C. Kelley. 1988. Alteration of North American streams by beaver. BioScience 38:753-761.

Naiman, R.J., J.R. Alldredge, D.A. Beauchamp, P.A. Bisson, J. Congleton, C.J. Henny, N. Huntly, R. Lamberson, C. Levings, E.N. Merrill, W.G. Pearcy, B.E. Rieman, G.T. Ruggerone, D. Scarnecchia, P.E. Smouse, C.C. Wood. 2012. River restoration and food webs. Proceedings of the National Academy of Sciences. 109(52):21201-21207. https://doi.org/10.1073/pnas.1213408109

Nickelson, T.E., J.D. Rodgers, S.L. Johnson and M.F. Solazzi. 1992. Seasonal changes in habitat use by juvenile Coho salmon (*Oncorhynchus kisutch*) in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Sciences. 49:790-794.

Nilsen, E. and J. Morace. 2014. Foodweb transfer, sediment transport, and biological impacts of emerging and legacy organic contaminants in the lower Columbia River, Oregon and Washington, USA: USGS Contaminants and Habitat (ConHab) Project. Science of the Total Environment. 484:319-321.

NMFS (National Marine Fisheries Service). 1996a. Status Review of West Coast Steelhead from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-27, August 1996.

NMFS (National Marine Fisheries Service). 1996b. Conclusions Regarding the Updated Status of West Coast Coho Salmon. December 20, 1996, NMFS-NWFSC Status Review Update Memo.

NMFS (National Marine Fisheries Service). 1997a. Scientific Disagreements Regarding Steelhead Status under the ESA. July 18, 1997, NMFS-NWFSC Status Review Update Memo.

NMFS (National Marine Fisheries Service). 1997b. Update for Deferred and Candidate ESUs of West Coast Steelhead. December 18, 1997, NMFS-NWFSC Status Review Update Memo.

NMFS (National Marine Fisheries Service). 1997c. Status Review of Chum Salmon from Washington, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-32, December 1997.

NMFS (National Marine Fisheries Service). 1998a. Update for Deferred ESUs of West Coast Steelhead, Hatchery Populations. January 13, 1998, NMFS-NWFSC/SWFSC Status Review Update Memo.

NMFS (National Marine Fisheries Service). 1998b. Status Review of Chinook Salmon from Washington, Idaho, Oregon, and California. NOAA Technical Memorandum NMFS-NWFSC-35, February 1998.

NMFS (National Marine Fisheries Service). 1998c. Conclusions Regarding the Updated Status of Puget Sound, Lower Columbia River, Upper Willamette River, and Upper Columbia River Spring-run ESUs of West Coast Chinook Salmon. December 23, 1998, NMFS-NWFSC Status Review Update Memo.

NMFS (National Marine Fisheries Service). 1999a. Conclusions Regarding the Updates Status of the Columbia River Chum Salmon ESU and Hood Canal Summer-run Chum Salmon ESU. February 12, 1999, NMFS-NWFSC Status Review Update Memo.

NMFS (National Marine Fisheries Service). 1999b. Evaluations of the Status of Chinook and Chum Salmon and Steelhead Hatchery Populations for ESUs Identified in Final Listing Determinations. March 4, 1999, NMFS-NWFSC Status Review Update Memo.

NMFS (National Marine Fisheries Service). 2005. Draft Interim Regional Recovery Plan for Portions of Three Evolutionarily Significant Units (ESUs) of Salmon and Steelhead—Columbia River Chinook (*Oncorhynchus tshawytscha*), Columbia River Chum (*Oncorhynchus keta*), and Lower Columbia River Steelhead (*Oncorhynchus mykiss*)—within the Washington Lower Columbia Management Unit. National Oceanic and Atmospheric Administration's National Marine Fisheries Service Supplement to the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan. Prepared by National Marine Fisheries Service Northwest Region. April 15, 2005.

NMFS (National Marine Fisheries Service). 2006. BiOp remand hatchery & harvest workgroup notes. Input to the Hatchery and Harvest Workgroup and the Policy Workgroup under the Federal Columbia River Power System Remand Collaboration. National Marine Fisheries Service, Northwest Region, September 27, 2006.

NMFS (National Marine Fisheries Service). 2007. Endangered Species Act Section 7 Consultation Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat Consultation. USFWS Artificial Propagation Programs in the Lower Columbia and Middle Columbia River. November 27, 2007. NMFS Consultation No.: NWR-2004-02625. 256p.

NMFS (National Marine Fisheries Service). 2008a. Endangered Species Act - Section 7 Consultation Biological Opinion. Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin, and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program. Portland, Oregon.

NMFS (National Marine Fisheries Service). 2008b. Biological Opinion: Impacts of *U.S. v Oregon* Fisheries in the Columbia River in Years 2008-2017 on ESA Listed Species and Magnuson-Stevens Act Essential Fish Habitat. May 5, 2008.

NMFS. 2008c. Recovery Plan for Southern Resident Killer Whales (*Orcinus orca*). National Marine Fisheries Service. Seattle, Washington. 251p.

NMFS (National Marine Fisheries Service). 2008d. Endangered Species Act – Section 7 Consultation Final Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation Implementation of the National Flood Insurance Program in the State of Washington Phase One Document – Puget Sound Region. NMFS Tracking No.: 2006-00472.

NMFS (National Marine Fisheries Service). 2010. Endangered Species Act - Section 7 Consultation Supplemental Biological Opinion. Supplemental Consultation on Remand for Operation of the Federal Columbia River Power System, 11 Bureau of Reclamation Projects in the Columbia Basin, and ESA Section 10(a)(I)(A) Permit for Juvenile Fish Transportation Program. Portland, Oregon. https://www.salmonrecovery.gov/Files/BiologicalOpinions/2010/FCRPS_Supplemental_2010_05-20[1].pdf

NMFS (National Marine Fisheries Service). 2013a. ESA Recovery Plan for Lower Columbia River Coho Salmon, Lower Columbia River Chinook Salmon, Columbia River Chum Salmon, and Lower Columbia River Steelhead. Northwest Region. 503 p.

NMFS (National Marine Fisheries Service). 2013b. Reinitiation of the Endangered Species Act Section 7 Formal Programmatic Conference and Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for Aquatic Restoration Activities in the States of Oregon and Washington (ARBO II). Seattle, Washington.

NMFS (National Marine Fisheries Service). 2014. Endangered Species Act Section 7(a)(2) Supplemental Biological Opinion – Consultation on Remand for Operation of the Federal Columbia River Power System, Northwest Region. Available at: http://www.westcoast.fisheries.noaa.gov/publications/hydropower/fcrps/2014_supplemental_fcrps_biop_final.pdf

NMFS (National Marine Fisheries Service). 2015a. Endangered Species Act Biological Opinion and Magnuson-Stevens Act Essential Fish Habitat (EFH) Consultation – Effects of the Pacific Coast Salmon Plan on the Lower Columbia River Coho Evolutionarily Significant

Unit Listed Under the Endangered Species Act. NMFS, West Coast Region. April 9, 2015. 66 p.

NMFS (National Marine Fisheries Service). 2015b. Jeopardy and Destruction or Adverse Modification of Critical Habitat Endangered Species Act Biological Opinion for The Environmental Protection Agency's Proposed Approval of Certain Oregon Water Quality Standards Including Temperature and Intergravel Dissolved Oxygen. NMFS Consultation Number WCR-2013-76.

NMFS (National Marine Fisheries Service). 2016a. 2016 5-Year Review: Summary and Evaluation of Lower Columbia River Chinook Salmon Columbia River Chum Salmon Lower Columbia River Coho Salmon Lower Columbia River Steelhead. NMFS, West Coast Region, Oregon/ Washington Coastal Office. May 26, 2016. 77p.

NMFS (National Marine Fisheries Service). 2016b. Endangered Species Act Section 7(a)(2) Biological Opinion Section 7(a)(2) Not Likely to Adversely Affect Determination and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Carson National Fish Hatchery Spring Chinook Salmon Program, Little White Salmon National Fish Hatchery Upriver Bright Fall Chinook Salmon Program, Little White Salmon National Fish Hatchery Spring Chinook Salmon Program, Eagle Creek National Fish Hatchery Coho Salmon Program, and Eagle Creek National Fish Hatchery Winter Steelhead Biological Opinion. August 30, 2016. NMFS Consultation Number: WCR-2016-5397. 210p.

NMFS (National Marine Fisheries Service). 2016c. Endangered Species Act (ESA) Section 7(a)(2) Jeopardy and Destruction or Adverse Modification of Critical Habitat Biological Opinion and Section 7(a)(2) "Not Likely to Adversely Affect" Determination for the Implementation of the National Flood Insurance Program in the State of Oregon. NMFS Consultation Number: NWR-2011-3197.

NMFS (National Marine Fisheries Service). 2017a. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation NOAA's National Marine Fisheries Service's implementation of the Mitchell Act Final Environmental Impact Statement preferred alternative and administration of Mitchell Act hatchery funding. NMFS Consultation Number: NWR-2014-697.

NMFS (National Marine Fisheries Service). 2017b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Consultation for the Mt. St. Helens Sediment Retention Structure, Project Phased Construction Alternative. NMFS Consultation Number: WCR-2014-1164. August 10, 2017.

NMFS (National Marine Fisheries Service). 2018a. 2009 Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat (EFH) Consultation. Hood River Spring Chinook

Salmon and Winter Steelhead Programs. February 13, 2018. NMFS Consultation Number: WCR-2017-7316. 188p.

NMFS (National Marine Fisheries Service). 2018b. Endangered Species Act (ESA) Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response. Consultation on effects of the 2018-2027 U.S. v. Oregon Management Agreement. February 23, 2018. NMFS Consultation Number: WCR-2017-7164. 597p.

NMFS (National Marine Fisheries Service). 2019a. Recovering Threatened and Endangered Species, FY 2017-2018 Report to Congress. National Marine Fisheries Service. Silver Spring, MD. 108p.

NMFS (National Marine Fisheries Service). 2019b. Three Year Review of the Lower Columbia River tule fall Chinook Abundance-based Harvest Matrix Agenda Item D.1.a. Supplemental NMFS Report 1. March 7, 2019. 9 p. Available online: https://www.pcouncil.org/documents/2019/03/agenda-item-d-1-a-supplemental-nmfs-report-3-final-three-year-review-of-the-lower-columbia-river-tule-fall-chinook-abundance-based-harvest-matrix-march-7-2019.pdf/

NMFS (National Marine Fisheries Service). 2019c. Three Year Review of the Lower Columbia River Natural Coho Abundance-based Harvest Matrix Agenda Item D.1.a. Supplemental NMFS Report 2. March 7, 2019. 8 p. Available online: https://www.pcouncil.org/documents/2019/03/agenda-item-d-1-a-supplemental-nmfs-report-2-final-three-year-review-of-the-lower-columbia-river-natural-coho-abundance-based-harvest-matrix-march-7-2019.pdf

NMFS (National Marine Fisheries Service). 2019d. Endangered Species Act Section 7(a)(2) biological opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat consultation for the continued operation and maintenance of the Columbia River System. NMFS Consultation Number: WCRO-2018-00152. National Marine Fisheries Service, West Coast Region. March 29, 2019.

NMFS (National Marine Fisheries Service). 2020a. Recovery Planning Handbook. Version 1.0. U.S. Department of Commerce, NOAA National Marine Fisheries Service. October 29, 2020.

NMFS (National Marine Fisheries Service). 2020b. Endangered Species Act Section 7(a)(2) Biological Opinion and Magnuson-Stevens Fishery Conservation and Management Act Essential Fish Habitat Response for the Continued Operation and Maintenance of the Columbia River System. July 24, 2020. NMFS Consultation Number WCRO-2020-00113. 1500p.

NMFS (National Marine Fisheries Service). 2022. Recovering Threatened and Endangered Species, FY 2019–2020 Report to Congress. National Marine Fisheries Service. Silver Spring, MD. Report available online at: https://www.fisheries.noaa.gov/resource/document recovering-threatened-and-endangered-species-report-congress-fy-2019-2020

NWFSC (Northwest Fisheries Science Center). 2015. Status Review Update for Pacific Salmon and Steelhead Listed under the Endangered Species Act: Pacific Northwest. December 21, 2015.

ODFW (Oregon Department of Fish and Wildlife): R. Beamesderfer, L. Berg, M. Chilcote, J. Firman, E. Gilbert, K. Goodson, D. Jepsen, T. Jones, S. Knapp, C. Knutsen, K. Kostow, B. McIntosh, J. Nicholas, J. Rodgers, T. Stahl and B. Taylor. 2010. Lower Columbia River Conservation and Recovery Plan for Oregon Populations of Salmon and Steelhead. Oregon Department of Fish and Wildlife, Salem, OR.

ODFW (Oregon Department of Fish and Wildlife). 2019. Annual Report: Pinniped Management at Bonneville Dam, 2019.

Ohlberger, J., D.E. Schindler, E.J. Ward, T.E. Walsworth, and T.E. Essington. 2019. Resurgence of an apex marine predator and the decline in prey body size. Proceedings of the National Academy of Sciences. 116(52):26682-26689.

Pearson, S.F., and S.J. Jeffries. 2018. Estimating Washington's coastal and inland harbor seal populations.

Pearson, W.H. and J.R. Skalski. 2011. Factors affecting stranding of juvenile salmonids by wakes from ship passage in the lower Columbia River. River Research and Applications. 27:926-936.

Pacific Fishery Management Council. 2021. Review of 2020 Ocean Salmon Fisheries: Stock Assessment and Fishery Evaluation Document for the Pacific Coast Salmon Fishery Management Plan. (Document prepared for the Council and its advisory entities.) Pacific Fishery Management Council, 7700 NE Ambassador Place, Suite 101, Portland, Oregon 97220-1384. Online at: https://www.pcouncil.org/documents/2021/02/review-of-2020-ocean-salmon-fisheries.pdf/

Phillips, B.F., and Pérez-Ramírez, M., eds. 2019. Climate Change Impacts on Fisheries and Aquaculture: A Global Analysis. 1048p. Wiley-Blackwell, Hoboken, New Jersey.

PNNL (Pacific Northwest National Laboratory). 2006. A study of Stranding of Juvenile Salmon by Ship Wakes along the Lower Columbia River Using a Before-an-After Design: Before-phase results. W. H. Pearson, G. E. Johnson, J. R. Skalski, G. D. Williams, K. L. Sobocinski, J. A. Southard, M. C. Miller, R. A. Buchanan. Prepared for the US Army Corps of Engineers, Portland District.

Pollock, M., G. Lewallen, K. Woodruff, C. Jordan, and J. Castro. 2017. The Beaver Restoration Guidebook: Working with Beaver to Restore Streams, Wetlands, and Floodplains. Version 2.0. United States Fish and Wildlife Service, Portland, Oregon

Quinn, T.P. 2005. The Behavior and Ecology of Pacific Salmon and Trout. University of Washington Press, Seattle, Washington.

Roby, D. D., K. Collis, P.J. Loschl, Y. Suzuki, D. Lyons, T.J. Lawes, K.S. Bixler, B. Caillouet, and B. Underwood. 2017. Avian predation on juvenile salmonids: Evaluation of the Caspian Tern Management Plan in the Columbia River estuary, 2016 final annual report. U.S. Geological Survey, Oregon State University, Corvallis, Oregon. March 21, 2017.

Roby, D.D., T.J. Lawes, D.E. Lyons, K. Collis, A.F. Evans, K.S. Bixler, S. Collar, O.A. Bailey, Y. Suzuki, Q. Payton, and P.J. Loschl. 2021. Chapter 1: Caspian tern management in the Columbia River estuary in D. D. Roby, A. F. Evans, and K. Collis (editors). Avian Predation on Salmonids in the Columbia River Basin: A Synopsis of Ecology and Management. A synthesis report submitted to the U.S Army Corps of Engineers, Walla Walla, Washington; the Bonneville Power Administration, Portland, Oregon; the Grant County Public Utility District/Priest Rapids Coordinating Committee, Ephrata, Washington; and the Oregon Department of Fish and Wildlife, Salem, Oregon. 788 pp.

Rub, A.M.W., N.A. Som, M.J. Henderson, B.P. Sandford, D.M. Van Doornik, D.J. Teel, M.J. Tennis, O.P. Langness, B.K. van der Leeuw, and D.D. Huff. 2019. Changes in adult Chinook salmon (*Oncorhynchus tshawytscha*) survival within the lower Columbia River amid increasing pinniped abundance. Canadian Journal of Fisheries and Aquatic Sciences. 76(10):1862-1873, https://doi.org/10.1139/cjfas-2018-0290.

Rubenson, E.S., D.J. Lawrence, and J.D. Olden. 2020. Threats to rearing juvenile Chinook salmon from nonnative smallmouth bass inferred from stable isotope and fatty acid biomarkers. Transactions of the American Fisheries Society. 149:350-363. https://doi.org/10.1002/tafs.10237

Rubenson, E.S., and J.D. Olden. 2016. Spatiotemporal spawning patterns of smallmouth bass at its upstream invasion edge. Transactions of the American Fisheries Society. 145:693-702. https://doi.org/10.1080/00028487.2016.1150880

Ryan, B.A., J.W. Ferguson, R.D. Ledgerwood, and E.P. Nunnallee. 2001. Detection of passive integrated transponder tags from juvenile salmonids on piscivorous bird colonies in the Columbia River basin. North American Journal of Fisheries Management. 21(2):417-421

Sanderson, B.L., K.A. Barnas and A.M.W. Rub. 2009. Non-indigenous species of the Pacific Northwest: an overlooked risk to endangered salmon? Bioscience. 59:245-256.

Schreck, C.B., M.L. Jent, M.E. Colvin, S. Benda, C. Sharpe, J.T. Peterson, and B. Dolan. 2013. Potential causes and management of prespawn mortality in adult Upper Willamette River spring Chinook. Report to the U.S. Army Corps of Engineers, Portland, OR.

Schtickzelle, N. and T.P. Quinn. 2007. A metapopulation perspective for salmon and other anadromous fish. Fish and Fisheries. 8:297-314.

Sebring, S.H., M.C. Carper, R.D. Ledgerwood, B.P. Sandford, G.M. Matthews, and A F. Evans. 2013. Relative vulnerability of PIT-tagged subyearling fall Chinook salmon to predation by Caspian terns and double-crested cormorants in the Columbia River estuary. Tranactions of the American Fisheries Society. 142:1321-1334.

Seigel, J. and L. Crozier. 2019. Impacts of Climate Change on Salmon of the Pacific Northwest. A review of the scientific literature published in 2018. Fish Ecology Division, NWFSC. December 2019.

Sorel, M.H., R.W. Zabel, D.S. Johnson, A.M. Wargo Rub, S.J. and Converse, S.J., 2021. Estimating population-specific predation effects on Chinook salmon via data integration. Journal of Applied Ecology. https://doi.org/10.1111/1365-2664.13772.

Sridhar, V., M.M. Billah, and J.W. Hildreth. 2018. Coupled surface and groundwater hydrological modeling in a changing climate. Groundwater 56(4):618-635.

TAC (U.S. v Oregon Technical Advisory Committee). 2015. TAC Annual Report. Abundance, Stock Status and ESA Impacts. 2015 Summary - Draft Report.

TAC (U.S. v Oregon Technical Advisory Committee). 2017. TAC Annual Report. Annual Summary Report of Fisheries.

TAC (U.S. v Oregon Technical Advisory Committee). 2018. TAC Annual Report. Annual Summary Report of Fisheries.

TAC (U.S. v Oregon Technical Advisory Committee). 2019. TAC Annual Report. Annual Summary Report of Fisheries.

TAC (U.S. v Oregon Technical Advisory Committee). 2020. TAC Annual Report. Annual Summary Report of Fisheries.

Thorne, K., G. MacDonald, G. Guntenspergen, R. Ambrose, K. Buffington, B. Dugger, C. Freeman, C. Janousek, L. Brown, .J. Rosencranz, J. Holmquist, J. Smol, K. Hargan and J. Takekawa. 2018. U.S. Pacific coastal wetland resilience and vulnerability to sea-level rise. Science Advances. 4(2):eaao3270.

Thom, B. 2020. Annual guidance letter from B. Thom, WCR Regional Administrator, NOAA NMFS to P. Anderson, Chair PFMC. February 27, 2020. 21p. online at: https://www.pcouncil.org/documents/2020/03/e-5-b-supplemental-nmfs-report-1-guidance-letter.pdf/

Thomas, A.C., B.W. Nelson, M.M. Lance, B.E. Deagle, and A.W. Trites. 2017. Harbour seals target juvenile salmon of conservation concern. Canadian Journal of Fisheries and Aquatic Sciences. 74(6):907-921.

Tidwell, K. S., R.I. Cates, D.A. McCanna, C.B Ford, B.K. van der Leeuw. 2020. Evaluation of

Pinniped Predation on Adult Salmonids and Other Fish in the Bonneville Dam Tailrace, 2019. U.S. Army Corps of Engineers, Portland District, Fisheries Field Unit. Cascade Locks, Oregon.

Tiffan, K.E., L.O. Clark, R.D. Garland, and D.W. Rondorf. 2006. Variables influencing the presence of subyearling fall Chinook salmon in shoreline habitats of the Hanford Reach, Columbia River. North American Journal of Fisheries Management. 26:351–360.

Tiffan, K.F., J.M. Erhardt, R.J. Hemingway, R.J. B.K Bickford, and T.N. Rhodes. 2020. Impact of smallmouth bass predation on subyearling fall Chinook salmon over a broad river continuum. Environmental Biology of Fishes. 103:1231-1246. https://doi.org/10.1007/s10641-020-01016-0

Tiffan, K.F., J.R, Hatten, and D.A. Trachtenbarg. 2016. Assessing juvenile salmon rearing habitat and associated predation risk in a lower Snake River reservoir. River Research and Applications. 32:1030-1038. https://doi.org/10.1002/rra.2934.

Twining, C.W., E.P. Palkovacs, M.A. Friedman, D.J. Hasselman, and D.M. Post. 2017. Nutrient loading by anadromous fishes: species-specific contributions and the effects of diversity. Canadian Journal of Fisheries and Aquatic Sciences. 74(4):609-619. https://doi.org/10.1139/cjfas-2016-0136

USACE (U.S. Army Corps of Engineers). 2015. Double-crested cormorant management plan to reduce predation on juvenile salmonids in the Columbia River estuary: Final Environmental Impact Statement. U.S. Army Corps of Engineers, Portland District, Portland, Oregon.

USFWS (U.S. Fish and Wildlife Service) and NMFS (National Marine Fisheries Service). 2006. 5-Year Review Guidance: Procedures for Conducting 5-Year Reviews Under the Endangered Species Act. July 2006.

Veilleux, H.D., J.M. Donelson, and P.L. Munday. 2018. Reproductive gene expression in a coral reef fish exposed to increasing temperature across generations. Conservation Physiology. 6:12.

Wade, A.A., T.J. Beechie, E. Fleishman, N.J. Mantua, H.Wu, J.S. Kimball, D.M. Stoms, and J.A. Stanford. 2013. Steelhead vulnerability to climate change in the Pacific Northwest. Journal of Applied Ecology. 50:1093-1104.

Wainwright, T.C. and L.A. Weitkamp. 2013. Effects of climate change on Oregon Coast coho salmon: habitat and life-cycle interactions. Northwest Science. 87:219-242.

Waples, R.S., R.W. Zabel, M.D. Scheuerell, and B.L. Sanderson. 2008. Evolutionary responses by native species to major anthropogenic changes to their ecosystems: Pacific salmon in the Columbia River hydropower system. Molecular Ecology. 17(1):84-96. https://doi.org/10.1111/j.1365-294x.2007.03510.x

WDFW (Washington Department of Fish and Wildlife). 2012. State of Washington Intensively Monitored Watershed Program: An Updated Plan to Monitor Fish and Habitat Responses to Restoration Actions in the Lower Columbia Watersheds. https://wdfw.wa.gov/sites/default/files/publications/01398/wdfw01398.pdf

WDFW (Washington Department of Fish and Wildlife). 2015. Lower Columbia Conservation and Sustainable Fisheries Plan. December 4, 2015. 365 p.

WDFW (Washington Department of Fish and Wildlife) and ODFW (Oregon Department of Fish and Wildlife). 2019. Joint staff report: Stock status and fisheries for fall chinook salmon, coho salmon, chum salmon, summer steelhead, and white sturgeon. Joint Columbia River Management Staff Report. 75 p. https://wdfw.wa.gov/publications/02085

Weitkamp, L.A., T.C. Wainwright, G.J. Bryant, G.B. Milner, D.J. Teel, R.G. Kope, and R.S. Waples. 1995. Status review of coho salmon from Washington, Oregon, and California. U.S. Dept. of Commerce, NOAA Tech. Memo., NMFS-NWFSC-24, 258 p.

Williams, R., M. Krkos, E. Ashe, T.A. Branch, S. Clark, P.S. Hammond, E. Hoyt, D.P. Noren, D. Rosen, and A. Winship. 2011. Competing conservation objectives for predators and prey: estimating killer whale prey requirements for Chinook salmon. PLoS ONE. 6(11):e26738.

Williams, S., E. Winther, and C. M. Barr. 2016. Report on the predation index, predator control fisheries, and program evaluation for the Columbia River basin Northern Pikeminnow Sport Reward Program. 2016 Annual Report, April 1, 2016 through March 31, 2017. Pacific States Marine Fisheries Commission, Portland, Oregon.

Williams, S., E. Winther, C. M. Barr, and C. Miller. 2017. Report on the predation index, predator control fisheries, and program evaluation for the Columbia River basin Northern Pikeminnow Sport Reward Program. 2017 Annual Report, April 1, 2017 through March 31, 2018. Pacific States Marine Fisheries Commission, Portland, Oregon.

Williams, S.E. Winther, C. Barr, C. Miller. 2018. Report on the predation index, predator control fisheries, and program evaluation for the Columbia River Basin Northern pikeminnow sport reward program. 2017 Annual Report. April 1, 2018 through March 31, 2019. Pacific States Marine Fisheries Commission, Portland, Oregon.

Winans, G.A., M.B. Allen, J. Baker, E. Lesko, F. Shrier, Strobel, B. and J. Myers, J., 2018. Dam trout: genetic variability in *Oncorhynchus mykiss* above and below barriers in three Columbia River systems prior to restoring migrational access. PloS ONE. 13(5):e0197571.

Winther, E., C. M. Barr, C. Miller, and C. Wheaton. 2019 Report on the predation index, predator control fisheries and program evaluation for the Columbia River Basin Northern Pikeminnow Sport Reward Program. 2019 Annual Report, April 1, 2019 through March 31, 2020. Pacific States Marine Fisheries Commission, Portland, Oregon.

WLCTRT (Willamette/Lower Columbia Technical Recovery Team). 2003. Interim Report on Viability Criteria for Willamette and Lower Columbia Basin Pacific Salmonids. March 31, 2003.

WLCTRT (Willamette/Lower Columbia Technical Recovery Team). 2004. Status Evaluation of Salmon and Steelhead Populations in the Willamette and Lower Columbia River Basin.

WLCTRT (Willamette/Lower Columbia Technical Recovery Team) and ODFW (Oregon Department of Fish and Wildlife). 2006. Revised Viability Criteria for Salmon and Steelhead in the Willamette and Lower Columbia Basins Review Draft. April 1, 2006.

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW

Lower Columbia River Chinook Salmon, (

Current Classification: Threatened

Recommendation resulting from the 5-Year Review

- [ ] Downlist to Threatened
- [ ] Uplist to Endangered
- [ ] Delist
- [x] No change is needed

Review Conducted By (Name and Office):

West Coast Region Lower Columbia River ESU/DPS Evaluation Team

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, NOAA Fisheries

Approve____________________ Digitally signed by Scott M. Rumsey Date: 2022.09.23 11:44:38 -07'00' Date: 9/23/22

Cooperating Regional Administrator, NOAA Fisheries

[ ] Concur [ ] Do Not Concur [x] N/A

Signature____ Date: _______

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

[x] Concur [ ] Do Not Concur

Signature RAUCH.SAMUEL.D.III.1365850948 Digitally signed by RAUCH.SAMUEL.D.III.1365850948 Date: 2022.10.07 14:19:39 -04'00' Date: _______