Science, Service, Stewardship

2024 5-Year Review: Summary & Evaluation of **California Coastal Chinook Salmon**

National Marine Fisheries Service
West Coast Region

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5-Year Review: California Coastal Chinook Salmon

Species Reviewed	Evolutionary Significant Unit
Chinook salmon (*Oncorhynchus tshawytscha*)	*California Coastal (CC) Chinook salmon*

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ACRONYMS

AIS	Aquatic Invasive Species
CDFW	California Department of Fish and Wildlife
CCC	Central California Coast
CMP	Coastal Management Plan
CVFF	Coyote Valley Fish Facility
DCFH	Don Clausen Fish Hatchery
DPS	Distinct Population Segments
EEZ	Exclusive Economic Zone
ESA	Endangered Species Act
ESU	Evolutionarily Significant Units
FMEP	Fisheries Management and Evaluation Plan
FMPs	Fishery Management Plans
GSA	Groundwater Sustainability Agencies
GSP	Groundwater Sustainability Plan
FIPs	Functionally Independent Populations
HGMP	Hatchery Genetic Management Plan
LCM	Life-Cycle Monitoring
MAUCRSA	Medicinal and Adult-Use Cannabis Regulation and Safety Act
MMPA	Marine Mammal Protection Act
NFIP	National Flood Insurance Program
NMFS	National Marine Fisheries Service
NPDES	National Pollution Discharge Elimination System
OSP	Optimum Sustainable Population
PCBs	Polychlorinated Biphenyls
PFMC	Pacific Fishery Management Council
PIPs	Potentially Independent Populations
RCP	Representative Concentration Pathway
RSI	Remote Site Incubators
SGMA	Sustainable Groundwater Management Act

SIS	Species in the Spotlight
SWFSC	Southwest Fisheries Science Center
TMDL	Total Maximum Daily Loads
TRT	Technical Recovery Teams
TDC	Thiamine Deficiency Complex
U.S.	United States of America
USACE	United States Army Corps of Engineers
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
VSP	Viable Salmonid Population

Contributors

West Coast Region (alphabetical)

Anthony Siniscal
1201 NE Lloyd Blvd, Suite 1100
Portland, Oregon 97232
971-322-8407
Anthony.Siniscal@noaa.gov

Nora Berwick (Retired)
1201 NE Lloyd Blvd, Suite 1100
Portland, Oregon 97232

Bob Coey (Retired)
777 Sonoma Avenue, Room 325
Santa Rosa, California 95404
707-575-6090
Bob.coey@noaa.gov

Tom Daugherty (Retired)
777 Sonoma Avenue, Room 325
Santa Rosa, California 95404

Joshua Fuller (Lead Author)
777 Sonoma Avenue, Room 325
Santa Rosa, California 95404
707-575-6096
Joshua.Fuller@noaa.gov

Mathew Goldsworthy
1655 Heindon Road
Arcata, California 95521
707-825-1625
Matt.Goldsworthy@noaa.gov

Jeffrey Jahn
1655 Heindon Road
Arcata, California 95521
707-217-9097
Jeffrey.Jahn@noaa.gov

Roman Pittman
1655 Heindon Road
Arcata, California 95521
707-825-5167
Roman.Pittman@noaa.gov

Southwest Fisheries Science Center

Nate Mantua
110 Shaffer Road
Santa Cruz, California 95060
831-420-3923
Nate.Mantua@noaa.gov

Michael O'Farrell
110 Shaffer Road
Santa Cruz, California 95060
831-420-3976
Michael.Ofarrell@noaa.gov

Brian Spence
110 Shaffer Road
Santa Cruz, California 95060
831-420-3902
Brian.Spence@noaa.gov

Thomas Williams
110 Shaffer Road
Santa Cruz, California 95060
831-420-3912
Thomas.Williams@noaa.gov

Northwest Fisheries Science Center

Lisa Crozier
2725 Montlake Boulevard East
East Building
Seattle, Washington 98112-2097
206-860-3395
Lisa.Crozier@noaa.gov

1. General Information

1.1 Introduction

Many West Coast salmon and steelhead (*Oncorhynchus spp*.) 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, climate change, and hatchery practices. These factors collectively led to NOAA's 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 5 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 2020). After completing this review, the Secretary must determine if any species should be: (1) removed from the list; (2) have its status changed from threatened to endangered; or (3) have its status changed from endangered to threatened. 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 (NMFS 2016b). This document describes the results of the 2024 5-year review of ESA-listed California Coastal Chinook salmon (CC Chinook salmon).

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 salmonid listing determinations

The ESA defines species to include subspecies and distinct population segments (DPSs) of vertebrate species. A species may be listed as threatened or endangered. To identify taxonomically recognized species of Pacific salmon NMFS utilizes the Policy on Applying the Definition of Species under the ESA to Pacific Salmon (56 FR 58612). Under this policy, NMFS identifies population groups that are evolutionarily significant units (ESUs) within taxonomically recognized species. NMFS considers 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 (56 FR 58612).

Artificial propagation programs (hatcheries) are common throughout the range of ESA-listed West Coast salmon and steelhead. Prior to 2005, our policy was to include in the listed ESU or DPS only those hatchery fish deemed essential for conservation of a species. We revised that approach in response to a court decision (U.S. District Court 2001). On June 28, 2005, we announced a final policy addressing the role of artificially propagated Pacific salmon and steelhead in listing determinations under the ESA (70 FR 37204) (Hatchery Listing Policy[1]). 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

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

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 new 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 37160), and for steelhead DPSs on January 5, 2006 (71 FR 834). On May 26, 2016, we published our most recent 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).

1.2 Methodology used to complete the review

On October 4, 2019, we announced the initiation of the 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 has 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, during the 5-year review process.

To complete the reviews, we first asked scientists from our Northwest and Southwest Fisheries Science Centers to collect and analyze new information about ESU and DPS viability. The scientists used the Viable Salmonid Population (VSP) concept developed by McElhany et al. (2000) to evaluate species viability. The VSP concept evaluates four criteria – abundance, productivity, spatial structure, and diversity – to assess species viability. Through the application of this concept, the science centers 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 delineation. At the end of this process, the science teams prepared reports detailing the results of their analyses (SWFSC 2022).

To further inform the reviews, we also asked salmon management biologists from the West Coast Region who are familiar with hatchery programs to consider new information available since the previous listing determinations. Among other things, they considered hatchery programs that have ended, new hatchery programs that have started, 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, water supply and reservoir operations, and harvest management. In a series of structured meetings by geographic area, these biologists identified relevant information and provided their insights on how circumstances have changed for each listed entity.

This report reflects the best available scientific information, including, the work of the Southwest Fisheries Science Center (SWFSC) (SWFSC 2022); reporting by the regional biologists regarding hatchery programs; findings in the 2016 Final Coastal Multispecies Recovery Plan for California Coastal Chinook Salmon, Northern California Steelhead and Central California Coast Steelhead (NMFS 2016a); technical reports prepared in support of the Final Coastal Multispecies Recovery Plan; the listing record (including designation of critical habitat and adoption of protective regulations); recent biological opinions issued for CC Chinook salmon; information submitted by the public and other government agencies; and the information and views provided by the geographically-based management teams. The 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

The CC Chinook salmon ESU was originally listed as a threatened species in 1999, and included several small hatchery stocks (64 FR 50394). In 2005, following a reassessment of its status and after applying NMFS Hatchery Listing Policy, we reaffirmed that the ESU continued to be threatened and also included several small hatchery stocks as part of the ESU (70 FR 37160) (Table 1). The 2011 5-year review determined all of the hatchery programs included as part of the ESU had been terminated, after which on April 14, 2014 a final rule was issued to update the description of the ESU to include only naturally spawned fish (79 FR 20802).

Table 1. Summary of the listing history under the Endangered Species Act for the CC Chinook salmon ESU.

Salmonid Species	ESU/DPS Name	Original Listing	Revised Listing(s)
Chinook salmon (*O. tshawytscha*)	California Coastal Chinook salmon	**FR Notice:** 64 FR 50394 **Date:** 9/16/1999 **Classification:** Threatened	**FR Notice:** 70 FR 37160 **Date:** 6/28/2005 **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 it is listed, on which are found those physical or biological features essential to the conservation of the species, and which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it is listed, upon determination by the Secretary that such areas are essential for the conservation of the species. We originally designated critical habitat for CC Chinook salmon in 2000 (65 FR 7764). We subsequently withdrew our designation for CC Chinook salmon in 2002 and later issued a new designation in 2005 (70 FR 52488) (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. Instead, it 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 account for our Hatchery Listing Policy.

Table 2. Summary of rulemaking for 4(d) protective regulations and critical habitat for the CC Chinook salmon ESU.

Salmonid Species	ESU/DPS Name	4(d) Protective Regulations	Critical Habitat Designations
Chinook salmon (*O. tshawytscha*)	California Coastal Chinook salmon	**FR notice:** 67 FR 1116 **Date:** 1/9/2002 **Revised:** 6/28/2005 (70 FR 37160)	**FR notice:** 70 FR 52488 **Date**: 9/2/2005

1.3.4 Review History

Table 3 lists the numerous scientific assessments of the status of the CC Chinook salmon ESU. These assessments include status reviews conducted by our Northwest and Southwest Fisheries Science Centers and technical reports prepared in support of recovery planning for this ESU.

Table 3. Summary of previous scientific assessments for the CC Chinook salmon ESU.

Salmonid Species	ESU/DPS Name	Document Citation
Chinook salmon (*O. tshawytscha)*	California Coastal Chinook salmon	SWFSC 2022 NMFS 2016b Williams et al. 2016 Williams et al. 2011 Spence et al. 2008 Bjorkstedt et al. 2005 Good et al. 2005 Myers et al. 1998 Busby et al. 1996

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 one (high) to 11 (low). This priority number reflects the species' demographic risk (based on the listing status and species' condition in terms of its abundance, productivity, spatial distribution, diversity), and recovery potential (major threats understood, management actions that exist under United States (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 2019). In December 2023, NMFS issued the 2021-2022 Recovering Threatened and Endangered Species Report to Congress (NMFS 2023) with updated recovery priority numbers. The number for the CC Chinook salmon ESU remained unchanged (NMFS 2023).

1.3.6 Recovery Plan or Outline

Table 4. Recovery Priority Number (2019) and Endangered Species Act Recovery Plan for the CC Chinook salmon ESU.

Salmonid Species	ESU/DPS Name	Recovery Priority Number	Recovery Plan/Outline
Chinook salmon (*O. tshawytscha*)	California Coastal Chinook salmon	3C	**Title:** Final Coastal Multispecies Recovery Plan Available at: https://www.fisheries.noaa.gov/resource/document/final-coastal-multispecies-recovery-plan-california-coastal-chinook-salmon **Date:** 2016 **Type:** Final **FR Notice:** 81 FR 70666

2. Review Analysis

In this section we review new information to determine whether the CC Chinook salmon ESU delineation remains appropriate.

2.1 Delineation of species under the Endangered Species Act

Is the species under review a vertebrate?

ESU/DPS Name	YES	NO
California Coastal Chinook salmon	X	

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

ESU/DPS Name	YES	NO
California Coastal Chinook salmon	X	

Was the ESU/DPS listed prior to 1996?

ESU/DPS Name	YES	NO	Date Listed if Prior to 1996
California Coastal Chinook salmon		X	n/a

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

In 1991, NMFS issued a policy explaining how the agency would apply the definition of "species" in evaluating Pacific salmon populations 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 ESU that meets the two criteria of: (1) being substantially reproductively isolated from other populations of the same taxonomically recognized species; and (2) representing an important component in the evolutionary legacy of the taxonomic species. The 1996 joint NMFS-U.S. Fish and Wildlife Service (USFWS) 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.

2.1.1 Summary of relevant new information regarding delineation of the CC Chinook salmon ESU

ESU Delineation

This section provides a summary of information presented in SWFSC 2022: Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. Recent information introduces the possibility that the geographic range of CC Chinook salmon may extend further south into tributaries of Tomales Bay, primarily the Lagunitas Creek watershed. However, there is currently no new published genetic information that would justify a change in the delineation of the CC Chinook salmon ESU at this time (SWFSC 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) 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 subsequent to the completion of the 5-year review process and prior to any official change in hatchery membership.

In the 2016 5-year review, the CC Chinook salmon ESU was defined as all naturally spawned Chinook salmon originating from rivers and streams south of the Klamath River to and including the Russian River (70 FR 37160, June 28, 2005). There are no hatchery programs in the CC Chinook salmon ESU. As part of this 5-year review, we re-evaluated the status of hatchery stocks and programs with regard to the Hatchery Listing Policy and reaffirmed that no hatchery programs warrant inclusion in the CC Chinook salmon ESU.

2.2 Recovery Criteria

The ESA requires NMFS to develop recovery plans 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 as may be 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 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).

For Pacific salmon, Technical Recovery Teams (TRTs), appointed by NMFS, define criteria to assess biological viability for each listed species. NMFS develops criteria to assess progress toward alleviating the relevant threats (listing factor [threats] criteria). NMFS adopts the TRT's viability criteria as the biological criteria for a recovery plan, based on best available scientific information and other considerations as appropriate. For the Final Coastal Multispecies Recovery Plan (NMFS 2016a), NMFS adopted the viability criteria metrics defined by the North Central California Coast Domain TRT as the biological recovery criteria for the threatened CC Chinook salmon ESU.

Biological reviews of the species continue as the recovery plan is implemented and additional information becomes available. The reviews consider new scientific analyses that can increase certainty about whether the threats have been abated, whether improvements in population biological viability have occurred for CC Chinook salmon, and whether linkages between threats and changes in salmon biological viability are understood. NMFS assesses the biological recovery criteria and the delisting criteria through the adaptive management program for the recovery plan during the ESA 5-Year Review (USFWS and NMFS 2006; NMFS 2020).

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

ESU/DPS Name	YES	NO
California Coastal Chinook salmon	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
California Coastal Chinook salmon	X	

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

ESU/DPS Name	YES	NO
California Coastal Chinook salmon	X	

2.2.3 List the biological recovery criteria as they appear in the recovery plan

For the purposes of reproduction, salmon and steelhead typically exhibit a metapopulation structure (McElhany et al. 2000; Schtickzelle and Quinn 2007). 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. Independent populations are a core group of extinction resistant and highly resilient populations. Dependent populations provide connectivity among independent populations, as well as temporary source populations and genetic refugia in the event of catastrophic loss of neighboring independent populations. The recovery scenario includes both independent and dependent populations.

The VSP concept (McElhany 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. 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 North Central California Coast Domain TRT developed viability criteria metrics based on the McElhaney et al. 2000 VSP concepts (Agrawal et al. 2005; Bjorkstedt 2005; Spence et al. 2008). The 2016 CC Chinook Recovery Plan (NMFS 2016a) adopted the North Central California Coast Domain TRT viability criteria as the biological recovery criteria for the threatened CC Chinook Salmon ESU. These criteria metrics describe population extinction risk in 100 years (Figure 1). NMFS color-coded the risk assessment to help readers distinguish the various risk categories.

		VSP Criteria Metrics			
		Spatial Structure/Diversity Risk			
		Very Low	Low	Moderate	High
Abundance/ Productivity Risk	Very Low (<1%)	Very Low Risk (Highly Viable)	Very Low Risk (Highly Viable)	Low Risk (Viable)	Moderate Risk
	Low (<5%)	Low Risk (Viable)	Low Risk (Viable)	Low Risk (Viable)	Moderate Risk
	Moderate (<25%)	Moderate Risk	Moderate Risk	Moderate Risk	High Risk
	High (>25%)	High Risk	High Risk	High Risk	High Risk

Figure 1. VSP Criteria Metrics from NMFS (2016a), adapted from Bjorkstedt et al. (2005) and Spence et al. (2008).

For recovery planning and development of recovery criteria, the North Central California Coast Domain TRT identified functional independent, potentially independent, and dependent populations within the CC Chinook salmon ESU and grouped them into regions of environmental (and presumably genetic) similarity termed Diversity Strata (Bjorkstedt et al. 2005 with modifications described in Spence et al. 2008). The ESU is composed of four diversity strata: North Coastal, North Mountain Interior, North-Central Coastal, and Central Coastal (Figure 2). The CC Chinook salmon ESU includes all naturally spawned Chinook salmon originating from rivers and streams south of the Klamath River to and including the Russian River (70 FR 37160, June 28, 2005).

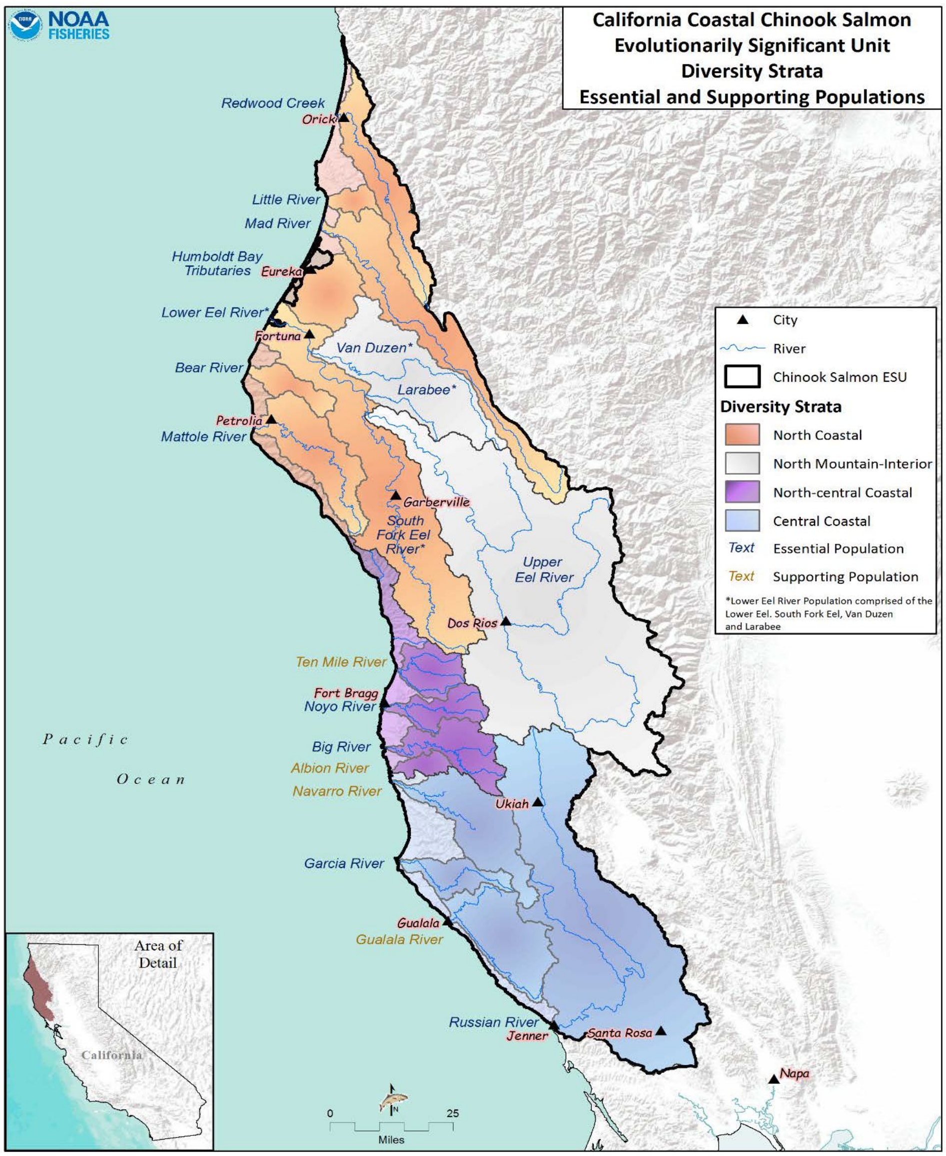

Figure 2. CC Chinook salmon ESU and Diversity Strata

Recovery strategies outlined in the 2016 Final Coastal Multispecies Recovery Plan are targeted on achieving, at a minimum, the biological viability criteria for each major diversity stratum in the ESU in order to have all four diversity strata at viable (low risk) status with representation of all the major life history strategies present historically, and with the abundance, productivity spatial structure, and diversity attributes required for long-term persistence. The plan recognizes that, at the diversity stratum level, there may be several specific combinations of populations that could satisfy the recovery criteria and identifies particular combinations of various populations that are the most likely to result in achieving diversity strata viability, and hence ESU viability.

The TRT recovery criteria are hierarchical in nature, with ESU level criteria being based on the status of natural-origin salmon assessed at the population level. Population extinction risk criteria (from Spence et al. 2008) are summarized below. A detailed description of the TRT viability criteria and their derivation (Spence et al. 2008 and Spence et al. 2012) can be found in Volume III of the 2016 Final Coastal Multispecies Recovery Plan (NMFS 2016a).

The four ESU viability criteria are:

(1) Representation Criteria

1.a. All identified Diversity Strata that include historical Functionally Independent Populations (FIPs) or Potentially Independent Populations (PIPs) within an ESU should be represented by viable populations for the ESU to be considered viable.

- AND

1.b. Within each Diversity Stratum, all extant phenotypic diversity (i.e., major life-history types) should be represented by viable populations.

(2) Redundancy and Connectivity

2.a. At least fifty percent of historically independent populations (FIPs or PIPs) in each Diversity Stratum must be demonstrated to be at low risk of extinction according to population viability criteria. For strata with three or fewer independent populations, at least two populations must be viable.

- AND

2.b. Within each Diversity Stratum, the total aggregate abundance of independent populations selected to satisfy this criterion must meet or exceed 50 percent of the aggregate viable population abundance (i.e., meeting density-based criteria for low risk) for all FIPs and PIPs.

(3) Remaining populations, including historically dependent populations or any historical FIPs or PIPs not expected to attain a viable status, must exhibit occupancy patterns consistent with those expected under sufficient immigration subsidy arising from the 'focus' independent populations selected to satisfy the preceding criterion.

(4) The distribution of extant populations, regardless of historical status, must maintain connectivity within the Diversity Stratum, as well as connectivity to neighboring Diversity Strata.

The 2016 Final Coastal Multispecies Recovery Plan identifies a set of most likely scenarios to meet the TRT's recommendations for low risk populations at the diversity stratum level. The following describes the combination of population status most likely to achieve viability for each diversity stratum for CC Chinook salmon (NMFS 2016a).

North Coastal Diversity Stratum

The Bear River, Humboldt Bay Tributaries, Little River, Lower Eel River (Lower Mainstem/ South Fork Eel River), Mad River, Mattole River, and Redwood Creek (Humboldt County) populations must reach at least *Viable* (low risk) status.

North Mountain Interior Diversity Stratum

The Lower Eel River (Larabee Creek/ Van Duzen River) and the Upper Eel River populations must reach at least *Viable* (low risk) status.

North-Central Coastal Diversity Stratum

The Big River and Noyo River populations must reach at least *Viable* (low risk) status;
The Ten Mile River population must reach at least moderate risk status; and
A supporting dependent population in Albion River must reach the established redundancy and occupancy criteria (Table 1 in Volume IV of the Final Coastal Multispecies Recovery Plan (NMFS 2016a)).

Central Coastal Diversity Stratum

1. The Garcia River and Russian River populations must reach at least *Viable* (low risk) status;
2. A supporting independent population in Gualala River must reach at least moderate risk status; and
3. A supporting population in Navarro River must reach the established redundancy and

occupancy criteria (Table 1 in Volume IV of the Final Coastal Multispecies Recovery Plan (NMFS 2016a)).

2.3 Updated Information and Current Species' Status

This section summarizes findings from the SWFSC 2022 – Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest (Subsection 2.3.1) SWFSC (2022) and our current ESA listing factor analysis (Subsection 2.3.2).

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 SWFSC 2022 – Viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest. Please see SWFSC (2022) for a more detailed discussion of each species' VSP status.

Updated Biological Risk Summary

Data availability and reliability for the CC Chinook salmon ESU has improved since the last viability assessment, particularly in the northern part of the ESU. Relatively new sonar-based monitoring programs in the Mad and Eel rivers, which have replaced index-reach surveys in a limited number of tributaries, indicate that populations in these watersheds are doing better than believed in prior assessments, with the Mad River population currently at levels above recovery targets. Likewise, sonar-based estimates for Redwood Creek suggest that the Redwood Creek population, while somewhat variable, is approaching its recovery target in favorable years. Trends in the longer time series are mixed, with the Freshwater Creek weir counts (one tributary of the Humboldt Bay population) showing a significant decline in abundance and Van Arsdale Fish Station trap counts (representing a small portion of the upper Eel River population) showing no significant trend in counts over the long (23-year) or short (12-year) time series, despite having below-average counts over the last 6 years. Again, interpretation of the Van Arsdale counts is potentially confounded by the relationship between stream discharge and the proportion of Chinook salmon adults reaching the counting station.

Data from populations in the more southerly diversity strata indicate that most populations (all except the Russian River) have exhibited mixed trends in abundance, but remain far below recovery targets. For many Mendocino Coast populations (Ten Mile, Noyo, Big, Navarro, Gualala, and Garcia rivers), surveys have failed to detect Chinook salmon in many of the past 12 years of monitoring, suggesting only sporadic occurrence in these watersheds. Concerns remain not only about the small population sizes in many watersheds, but the maintenance of population connectivity across the ESU. That said, the TRT noted high uncertainty regarding the historical occurrence of independent populations on the Mendocino Coast from the Ten Mile River south to the Gualala River (Bjorkstedt et al. 2005); thus, the overall implications of low numbers in these populations on ESU viability are likewise somewhat uncertain. Only the Russian River population has consistently numbered in the low thousands of fish in most years, making it the largest population south of the Eel River. In summary, currently available information indicates that recent trends across the ESU have been mixed and that overall extinction risk for the ESU is moderate and has not changed appreciably since the 2016 viability assessment.

2.3.2 Analysis of ESA Listing Factors

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 determinations solely on the basis of the best scientific and commercial data available, after conducting a review of the status of the species and accounting for 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

Significant habitat restoration and protection actions at the Federal, state, and local levels have been implemented to improve degraded habitat conditions and restore fish passage. 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 continues to be monitored and evaluated with the aid of new reporting techniques. Generally, it takes 1 to 5 decades to demonstrate such increases in viability.

Current Status and Trends in Habitat

Below, we summarize information on the current status and trends in habitat conditions by Diversity Stratum since our last 2016 5-year review. 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 (e.g., independent population major/minor spawning areas) where key emergent or ongoing concerns about this habitat condition remain; (3) population-specific key habitat protective measures and major habitat restoration actions taken since the 2016 5-year review toward achieving the recovery plan viability criteria adopted by NMFS in the 2016 Final Coastal Multispecies Recovery Plan (NMFS 2016a) 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 5 years toward achieving population viability, including, key near-term habitat 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.

North Coastal Diversity Stratum

1) Population-Specific Key Emergent or Ongoing Habitat Concerns Since the 2016 5-Year Review

For the seven essential independent populations comprising the North Coastal Diversity Stratum (Bear River, Humboldt Bay Tributaries, Little River, Mad River, Mattole River, Redwood Creek, and Lower Mainstem/South Fork Eel River), the primary habitat concerns reported in 2016 5-year review (NMFS 2016b) continue to be:

- Reduced pool depth and habitat complexity has significantly altered staging pool and habitat quality for adult Chinook salmon in the Lower Mainstem Eel River; especially, for early fall arriving adults and during prolonged drought conditions. Shallow staging pools without adequate habitat complexity leaves adult Chinook salmon vulnerable to illegal poaching, increased predation, poor water quality conditions, and disease due to high levels of stress.

- Loss of natural estuarine function, habitat complexity, floodplain connectivity, and impaired outmigration due to constraining levee placement has significantly reduced habitat conditions for juvenile Chinook salmon in lower Redwood Creek and Lower Mainstem/ South Fork Eel River.

- Reduced instream flows associated with climate change have prolonging estuary closures, contributing to poor water quality conditions further reducing essential habitat for rearing juvenile Chinook salmon prior to ocean entry in the Little River, Mad River, Mattole River, and Redwood Creek estuaries.
- Reduced instream flows due to groundwater use and diversions in the mainstem and lower Eel River watershed have disrupted the natural flow regime, further reducing migratory and estuarine habitat for juvenile and adult Chinook salmon in the Eel River watershed.

- Loss of the historic quality and extent of estuarine habitat has significantly reduced the production capacity of juvenile Chinook salmon rearing within all populations of the North Coastal Diversity Stratum.

2) Population-Specific Geographic Areas of Habitat Concern Since the 2016 5-Year Review

- Prolonged drought patterns are impacting water quantity, quality and timing for adult Chinook salmon migration to desired spawning habitat, particularly in the southern portion of the North Coastal Diversity Stratum (CDFW 2020). The lower mainstems and estuaries of Bear River, Little River, Mad River, Mattole River, Redwood Creek, and the Lower Mainstem of the Eel River are the population-specific geographic areas of habitat concern within the North Coastal Diversity Stratum.

- Significant retreat and fragmentation of eelgrass resources in multiple areas of Humboldt Bay due to eelgrass wasting disease. The reductions in spatial coverage of eelgrass and the corresponding decrease in eelgrass biomass disrupts ecosystem processes and the overall resilience of Humboldt Bay to the effects of climate change, including ocean acidification and sea level rise. Eelgrass provides prey resources and cover, both as living plants and as dead floating eelgrass wrack, which are essential features documented to be important for the outmigration of smolt life stages in Humboldt Bay (Pinnix et al. 2013). Reductions in eelgrass biomass has and will continue to reduce the quality and quantity of estuarine and migratory habitat elements for Chinook salmon that occupy Humboldt Bay Tributaries.

3) Population-Specific Key Habitat Protective Measures and Major Restoration Actions Taken Since the 2016 5-Year Review

The key protective measures and major restoration actions addressing population-specific habitat concerns in the North Coastal Diversity Stratum implemented since adoption of the Recovery Plan in 2016 and the 2016 5-year review are:

- Improved habitat complexity in Little River watershed (Humboldt County) resulting from the installation of 12 habitat structures (9,638 square feet) along 1.05 miles of stream (CDFW 2020). These improved habitat complexity features support the recovery of Little River CC Chinook salmon population.

- Improved habitat complexity in the South Fork Eel River watershed in support of the recovery of the Lower Mainstem/SF Eel River CC Chinook salmon population (CDFW 2020) by the:
    - construction of 32 habitat structures (1,582 square feet) along 1.13 miles of stream;
    - planting of 2 acres of riparian habitat;
    - treatment of 0.04 acres of invasive plant species along 1.13 miles of streambank;
    - addition of instream structures to Hollow Tree Creek, Anderson Creek, and Redwood Creek.

- Improved habitat complexity in the Eel River watershed supporting the recovery of all CC Chinook salmon populations in the Eel River watershed (CDFW 2020) by the:
    - installation of 26 habitat structures (1,525 square feet) along 1.05 miles of stream;
    - planting of 2 acres of riparian habitat;
    - hydraulic reconnection of freshwater tributaries and floodplains to ~3 miles of estuary slough.

- Improved habitat complexity in Salmon Creek (Humboldt Bay) in support of the recovery of the CC Chinook salmon Humboldt Bay Tributaries population (CDFW 2020) by the:
    - installation of instream habitat structures;
    - completion of road decommissioning projects in Morrison Creek and Ryan Creek.

- Improved hydrologic, sediment transport, wetland, and floodplain function in the Salt River watershed (Eel River) by restoring geomorphic features and tidal influence and reducing sedimentation from upper tributary watersheds. The project is partially completed on the Salt River and will benefit the Eel River estuary and all CC Chinook salmon populations within the Eel River.

4) Key Regulatory Measures Since the 2016 5-Year Review

The NMFS 2016 Coastal Multispecies Recovery Plan (NMFS 2016a) and the previous 5-year review identified inadequate regulatory mechanisms as a priority issue affecting CC Chinook recovery in the North Coastal Diversity Stratum. Various federal, state, county and tribal regulatory mechanisms are in place to minimize or avoid habitat degradation caused by human use and development. Although many of these mechanisms have been improved and updated in the past 5 years, the implementation and effectiveness of these land use regulations remain a concern. ***See Listing Factor D: Inadequacy of Existing Regulatory Mechanisms in this document for details.***

5) Recommended Future Recovery Actions Over the Next 5 Years Toward Achieving Population Viability

The greatest opportunities to advance recovery of CC Chinook salmon in the North Coastal Diversity Stratum are the following:

- Address the shallow and simplified holding and staging habitat in the lower Eel River through a combination of short-term actions to improve complexity and promote pool scour and to address the lack of tidal prism and geomorphic dysfunction in the lower river to improve sediment routing and increase depths and complexity. This recovery action will support all CC Chinook salmon populations within the Eel River watershed.

- Improve floodplain connectivity and enhance juvenile Chinook salmon rearing habitat conditions via installing setback levees on lower Redwood Creek to restore estuarine, riparian, and fluvial function. This recovery action will support the Redwood Creek CC Chinook salmon population.

- Evaluate the significant retreat of eelgrass in Humboldt Bay, and address any stressors identified in causing severe eelgrass wasting disease and similar eelgrass loss to support the recovery of the Humboldt Bay Tributaries CC Chinook salmon population.

- Manage municipal water right allocations with groundwater use and diversions as part of the Lower Eel Groundwater Sustainability planning effort to improve instream flow in the Eel River watershed. This recovery action will support all CC Chinook salmon populations within the Eel River watershed.

- Complete full implementation of the Little River Estuary Enhancement Project to support the recovery of the Little River Chinook salmon population.

- Complete all phases of the lower Salt River Ecosystem Restoration Project (lower Eel River) and other proposed habitat expansion sites to improve the Eel River estuary. This recovery action will support all CC Chinook salmon populations within the Eel River watershed.

North Mountain Interior Diversity Stratum

1) Population-Specific Key Emergent or Ongoing Habitat Concerns Since the 2016 5-Year Review

For the two essential independent populations comprising the North Mountain Interior Diversity Stratum (Lower Eel River: Larabee Creek/Van Duzen River and Upper Eel River), the primary habitat concerns reported in 2016 5-year review (NMFS 2016b) continue to be:

Altered Eel River watershed river conditions associated with the Potter Valley Project (Project), located within the Upper Eel River Chinook salmon population geographic-area include:

- Project operations have significantly disrupted the natural migratory cues for Chinook salmon smolts due to an altered temperature regime. Disruptions to important temperature cues cause delay for some outmigrating Chinook salmon smolts resulting in the untimely arrival to the lower Eel River when water temperature are unfavorable for survival.
- Inadequate reservoir storage in Lake Pillsbury associated with the operations of Scott Dam significantly impacts timely water releases for spring and fall migrating juvenile and adult Upper Eel River Chinook salmon.
- Non-compliant and inadequate fish passage at the Cape Horn Dam Fish Passage Facility can cause migratory and spawning delays that potentially reducing spawning success of adult Upper Eel River Chinook salmon within the Project area.
- Inaccessibility to nearly 100 miles of high-value habitat to Upper Eel River Chinook salmon due to Scott Dam. This barrier significantly reduces the production capacity of the Upper Eel River Chinook salmon population.

Other ongoing habitat concerns in the North Mountain Interior Diversity Stratum include:

- Upstream passage impediments caused by gravel mining operations contributing to hydraulic and planform changes at the mouth of the Van Duzen River resulting in stranding and mortality of Van Duzen River adult Chinook salmon during early and flow periods.
- Reduced instream flows due to groundwater use and diversions in the mainstem and lower Eel River watershed have disrupted the natural flow regime, further reducing migratory and estuarine habitat for juvenile and adult Chinook salmon in both the Lower Eel River and Upper Eel River populations.

2) Population-Specific Geographic Areas of Habitat Concern Since the 2016 5-Year Review

- Prolonged drought patterns are impacting water quantity, quality and timing for adult Chinook salmon migration to desired spawning habitat, particularly in the southern portion of the North Coastal Diversity Stratum (CDFW 2020). The lower mainstems and estuaries of Bear River, Little River, Mad River, Mattole River, Redwood Creek, and the Lower Mainstem of the Eel River are the populations that have the most specific geographic areas of habitat concern within the North Coastal Diversity Stratum.

3) Population-Specific Key Habitat Protective Measures and Major Restoration Actions Taken Since the 2016 5-Year Review

Since adoption of the Recovery Plan in 2016, and the 2016 5-year review, the following key habitat measures and restoration actions have addressed habitat concerns in the North Mountain Interior Diversity Stratum:

- Restored fish passage in Woodman Creek to several miles of habitat in the upper Eel River watershed, supporting the recovery of the Upper Eel River CC Chinook salmon population.

- Improved Lake Pillsbury water temperature management, strategic blockwater water releases (i.e., an allocation of reservoir water storage for ecological purposes outside prescribed flow releases from the Potter Valley Project), and warmer water release strategies when available, have improved migratory cues and habitat conditions for juvenile and adult Chinook salmon in the Eel River.

- Improved infrastructure and modifications to the Cape Horn Dam Fish Passage Facility aim to reduce prolonged fish ladder closures during intense high sediment load storm events. Monitoring and performance metrics are in place to determine the effectiveness of these improvements for fish passage availability over Cape Horn Dam (2020). The results of these improvements are anticipated to benefit adult Upper Eel River Chinook salmon; however, the passage facility still remains non-complaint with current fish passage guidelines.

- Improved hydrologic, sediment transport, wetland, and floodplain function in the Salt River watershed (Eel River) by restoring geomorphic features and tidal influence and reducing sedimentation from upper tributary watersheds. The project is partially completed on the Salt River and will benefit the Eel River estuary and all CC Chinook salmon populations within the Eel River.

4) Key Regulatory Measures Since the 2016 5-Year Review

The NMFS 2016 Coastal Multispecies Recovery Plan (NMFS 2016a) and the previous 5-year review identified inadequate regulatory mechanisms as a priority issue affecting CC Chinook recovery in the North Mountain Interior Diversity Stratum. Various federal, state, county and tribal regulatory mechanisms are in place to minimize or avoid habitat degradation caused by human use and development. Although many of these mechanisms have been improved and updated in the past 5 years, the implementation and effectiveness of these land use regulations remain a concern. See ***Listing Factor D: Inadequacy of Existing Regulatory Mechanisms in this document for details.***

5) Recommended Future Actions Over the Next 5 Years Toward Achieving Population Viability

The greatest opportunities to advance recovery of CC Chinook salmon in the North Mountain Interior Stratum are the following:

- Decommission Scott Dam, Lake Pillsbury, and restore access to nearly a hundred miles of high-quality habitat in the upper Eel River. Once achieved, this action will significantly contribute to the recovery of the Upper Eel River Chinook salmon population and the greater ESU.

- Decommission the current Cape Horn Dam Fish Passage Facility and ensure timely, efficient and effective safe fish passage for juvenile and adult Chinook salmon as they ascend to the upper Eel River. Once achieved, this action will significantly contribute to the recovery of the Upper Eel River Chinook population and the greater ESU.

- Full implementation of NMFS' Interim Protective Measures, including water temperature management and adjustments to water release strategies associated with Lake Pillsbury water storage and Scott Dam operations. Improved water storage management and water releases will support the recovery of the Upper Eel River Chinook salmon population.

- Address the unlimited use of groundwater wells and groundwater pumping on surface flows. This recovery action will support all Chinook salmon populations within the upper and lower Eel River watershed.

- Continue to develop and implement gravel mining strategies that enhance lower Van Duzen River low-flow fish passage conditions for adult Chinook salmon. This recovery action will primarily support the Larabee Creek/Van Duzen River Chinook salmon population.

- Complete all phases of the lower Salt River Ecosystem Restoration Project (Eel River estuary) and other proposed habitat expansion sites to improve the Eel River estuary. This recovery action will support all CC Chinook salmon populations within the upper and lower Eel River watershed.

North Central Coastal Diversity Stratum

1) Population-Specific Key Emergent or Ongoing Habitat Concerns Since the 2016 5-Year Review

For the two essential independent populations comprising the North Central Coastal Diversity Stratum (Big River and Noyo River), the one supporting independent population (Ten Mile River), and the one dependent population contributing to redundancy and occupancy (Albion River), the primary habitat concerns reported in 2016 5-year review (NMFS 2016b) continue to be:

- Remaining significant debris from past timber harvest and road-related sediment delivery to stream channels in the Big River, Noyo River, Albion River, and Ten Mile River, resulting in reduced spawning gravel and juvenile rearing habitat quality for CC Chinook salmon.

- Loss of the historic quality and extent of estuarine habitat due to various anthropogenic alternations have reduced the habitat production capacity for juvenile Chinook salmon in the Big River, Noyo River, and Albion River.

- Limited mainstem spawning habitat availability to CC Chinook salmon in the lower Albion River when droughts limits access to more appropriate CC Chinook salmon spawning locations farther upstream.

2) Population-Specific Geographic Areas of Habitat Concern Since the 2016 5-Year Review

- Cumulative effects from past timber management increasing wildfire risk. Predicted warmer temperatures and more frequent, severe droughts, which create extremely dry forest conditions that are more conducive to ignition and expansion, are a risk to the larger populations that span warmer inland areas of the North-Central Coastal Diversity Stratum.

3) Population-Specific Key Protective Measures and Major Restoration Actions Taken Since the 2016 5-Year Review

Since adoption of the Recovery Plan in 2016, and the 2016 5-year review, the following key measures and restoration actions have addressed habitat concerns in the North Central Coastal Diversity Stratum:

- Several LWD projects have been implemented in some mainstem reaches of Ten Mile, Noyo and Albion Rivers to improve spawning habitat and high flow survival of juvenile Chinook salmon.

- Protection of the North Central Coast Diversity Stratum CC Chinook salmon with the implementation of the California Department of Fish and Wildlife freshwater sport fishing low flow closure regulations along the Mendocino coast (2016).

- The Nature Conservancy implemented phase 1 of a restoration action plan that was highlighted in NMFS' Species in the Spotlight Initiative. The first phase restored habitat at five sites in the lower South Fork Ten Mile River, including multiple engineered log jams and a sizeable wetland pond that will provide refuge and rearing habitat for juvenile Chinook salmon. This action supports the recovery of the CC Chinook salmon North Central Coast Diversity Stratum.

4) Key Regulatory Mechanisms Since the 2016 5-Year Review

The NMFS 2016 Coastal Multispecies Recovery Plan (NMFS 2016a) and the previous 5-year review identified inadequate regulatory mechanisms as a priority issue affecting CC Chinook recovery in the North Central Coastal Diversity Stratum. Various federal, state, county and tribal regulatory mechanisms are in place to minimize or avoid habitat degradation caused by human use and development. Although many of these mechanisms have been improved and updated in the past 5 years, the implementation and effectiveness of these land use regulations remain a concern. ***See Listing Factor D: Inadequacy of Existing Regulatory Mechanisms in this document for details.***

5) Recommended Future Actions Over the Next 5 Years Toward Achieving Population Viability

The greatest opportunities to advance recovery of CC Chinook salmon in the North Central Coastal Diversity Stratum are the following:

- Continue upgrading and decommissioning roads to reduce the effects of increased large flood events expected from climate change. This action will support the recovery of the CC Chinook salmon North Central Coast Diversity Stratum by increasing spawning habitat capacity.
- Develop and implement projects to reduce fuel loading in watershed areas with high fire potential. This action will support the recovery of the CC Chinook salmon North Central Coast Diversity Stratum by protecting spawning and rearing habitat.
- Implement additional LWD improvement projects in mainstem reaches of the Big River and the Noyo River. This action will support the recovery of the CC Chinook salmon North Central Coast Diversity Stratum by improving rearing habitat and production capacity.
- Extend and complete implementation of the Lower Ten Mile River estuary restoration project. This action will support the recovery of the CC Chinook salmon North Central Coast Diversity Stratum by improving rearing habitat, smolt survival, and overall production capacity.
- Develop and implement estuary habitat enhancement projects within the Big River, Noyo River, and Albion River. This action will support the recovery of the CC Chinook salmon North Central Coast Diversity Stratum by improving rearing habitat, smolt survival, and overall production capacity.

Central Coastal Diversity Stratum

1) Population-Specific Key Emergent or Ongoing Habitat Concerns Since the 2016 5-Year Review

For the two essential independent populations comprising the Central Coastal Diversity Stratum (Garcia River and Russian River) and the two supporting independent populations (Navarro River and Gualala River), the primary habitat concerns reported in 2016 5-year review (NMFS 2016b) continue to be:

- Extensive drought conditions resulting in low reservoir water storage and constrained water operations limit the ability to provide adult Chinook salmon migration and spawning flows released from Lake Sonoma and Lake Mendocino, Russian River.

- Fall season artificial breaching of the Russian River estuary mouth disrupts the natural migratory cues for adult Chinook salmon resulting in early in-river entry when watershed conditions are unsuitable (e.g., poor passage flows, higher water temperatures, and higher predation risk).

- Chronic turbidity and suspended sediment issues associated with Lake Mendocino flow releases significantly contribute to poor mainstem Chinook salmon spawning gravel and reduces the quality of salmon rearing conditions (e.g., food availability and foraging) in the Russian River.

- Reduced floodplain connectivity in the Russian River due to historic land use, flood control and water supply management limits the duration of inundation of high-quality wet season habitat that provide important rearing opportunities for juvenile Chinook salmon.

- Extensive and/or prolonged hydrologic drought conditions exacerbating Garcia River, Navarro River, and Gualala River instream flow conditions resulting in impacts to juvenile and adult Chinook salmon migration opportunities and population production capacity.

- Extensive and/or prolonged hydrologic drought conditions impacting Navarro River and Gualala River instream river mouth dynamics (timely lagoon/estuary breaches, etc.), potentially delay Chinook salmon migration timing and spawning success.

- Reduced estuary habitat quality (e.g., water quality and physical habitat complexity, etc.) and extent limits rearing opportunities and likely increases avian and aquatic predation risk to juvenile Chinook salmon in the Russian River, Gualala River, and Navarro River.

2) Population-Specific Geographic Areas of Habitat Concern Since the 2016 5-Year Review

There is no additional population-specific geographic areas of concern beyond the Russian River, Garcia River, Navarro River, and Gualala River than the habitat concerns identified above.

3) Population-Specific Key Protective Measures and Major Restoration Actions Taken Since the 2016 5-Year Review

Since adoption of the Recovery Plan in 2016, and the 2016 5-year review, the following key measures and restoration actions have addressed habitat concerns in the Central Coastal Diversity Stratum:

- Successful implementation of NOAA's Habitat Blueprint: Russian River Habitat Focus Area. This was an important step to increase the effectiveness of NOAA's habitat conservation science and management efforts by targeting multiple habitat conservation objectives aimed to rebuild Russian River salmonids to sustainable levels through habitat protection and restoration. NOAA's National Weather Service has improved frost, rainfall, and river forecasts in the Russian River watershed through advanced data collection and modeling for the purpose of improving streamflows by decreasing withdrawals from irrigation activities.

- Successful implementation of Forecast Informed Reservoir Operations (FIRO) pilot study contributes to improved water storage reliability and water temperature management in Lake Mendocino, thereby increasing potential for fall/early winter reservoir releases for Chinook salmon migration in the upper Russian River.

- Successful implementation of the Garcia River Estuary Enhancement Project. Implementation of this project has significantly improved habitat complexity for adult and juvenile Chinook salmon in the Garcia River.

4) Key Regulatory Measures Since the 2016 5-Year Review

The NMFS 2016 Coastal Multispecies Recovery Plan (NMFS 2016a) and the previous 5-year review identified inadequate regulatory mechanisms as a priority issue affecting CC Chinook salmon recovery in the Central Coastal Diversity Stratum. Various federal, state, county and tribal regulatory mechanisms are in place to minimize or avoid habitat degradation caused by human use and development. Although many of these mechanisms have been improved and updated in the past 5 years, the implementation and effectiveness of these land use regulations remain a concern. ***See Listing Factor D: Inadequacy of Existing Regulatory Mechanisms in this document for details.***

5) Recommended Future Actions Over the Next 5 Years Toward Achieving Population Viability

The greatest opportunities to advance recovery of CC Chinook in the Central Coastal Diversity Stratum are the following:

1. Improve reservoir management strategies to ensure adequate water quality and flow conditions for juvenile and adult Chinook salmon habitat production capacity in the upper Russian River.

2. Permanently implement FIRO for both Lake Mendocino and Lake Sonoma reservoirs to provide more storage reliability in the Russian River, resulting in improved Chinook salmon migration and spawning flow conditions in most years.

3. Reduce upper Russian River turbidity and temperature issues associated with Lake Mendocino in the next Russian River biological opinion. This action will greatly support the recovery of the Russian River Chinook salmon population by improving the quality of spawning and rearing habitat.

4. Mitigate for Russian River estuary management via habitat enhancement opportunities to be included in the next Russian River biological opinion to improve habitat production capacity and predation protection of juvenile and adult Chinook salmon. When implemented, this effort will support the overall recovery of the Russian River Chinook salmon population.

5. Evaluate and develop actions aimed to rehabilitate gravel pits in the Russian River that offer valuable floodplain type habitat and reduce invasive fish species productivity and predation on juvenile Chinook salmon. When implemented, this effort will support the overall recovery of the Russian River Chinook salmon population.

6. Continue to fund and implement the Garcia River Estuary Enhancement Plan. Garcia River estuary habitat enhancements will greatly improve the habitat production capacity and predation protection for juvenile and adult Chinook salmon. When fully completed, this effort will support the overall recovery of the Garcia River Chinook salmon population.

7. Evaluate the potential to reinstate the Chinook salmon propagation program at Warm Spring Hatchery. Potentially consider this program as a CC Chinook salmon conservation hatchery that supports the entire Central Coastal Diversity Stratum.

8. Evaluate and implement strategies to improve low-flow conditions that significantly impair juvenile and adult Chinook salmon migration opportunities in the Garcia, Navarro, and Gualala rivers to increase the resiliency of these Chinook salmon populations, particularly during prolonged dry fall and spring hydrologic conditions.

9. Evaluate and implement estuary habitat enhancement strategies to support juvenile and adult Chinook salmon in the Gualala River and Navarro River watersheds. When implemented, these efforts will support the overall recovery of the Gualala River and Navarro River Chinook salmon populations.

ESU Summary

The risk to the species' persistence because of habitat destruction or modification has not changed significantly since the last 5-year review. Major habitat concerns remain in this ESU particularly with regard to (1) water quantity and quality associated with reservoir management and operations; (2) fish passage; (3) impairment to estuary quality and extent; and (4) reduced habitat complexity: primary pools juvenile rearing and adult staging**.**

Listing Factor A: Conclusion

New information available since the last 5-year review indicates there has been some improvement in freshwater and estuary habitat conditions because of restoration efforts and habitat protection. However, prolonged droughts and climate change have resulted in a higher frequency of low-flow conditions during the fall and spring throughout the CC Chinook salmon ESU. This has limited the productivity of the habitat and reduced the potential for habitat restoration efforts to support the conditions that CC Chinook salmon need to prosper. We, therefore, conclude that the risk to the species' persistence because of habitat destruction or modification has not changed significantly since the last 2016 5-year review (NMFS 2016b), and remains high.

As mentioned above, habitat concerns specific to cold water resources and timing of water availability appear to be getting worse due to water reliability limitations through much of the ESU. Specifically, in watersheds (Russian River and Eel River populations) where fall and spring stream flows are highly regulated by reservoir releases and are further constrained by water quality and quantity concerns due to anthropogenic alternations. There remain numerous opportunities for habitat restoration or protection throughout the range of this ESU, the most significant being the expansion of spawning and rearing habitat production capacity through the removal of Scott Dam on the Eel River, enhancement of Russian River mainstem spawning and rearing habitat quality through Lake Mendocino releases due to improved water storage reliability, and the reduction of chronic turbidity while maintaining cooler water temperatures.

Estuary restoration in the Ten Mile, and Eel rivers and future opportunities in the Garcia, Eel, Russian, Noyo, and Big rivers should be pursued in the future to increase the juvenile and smolt survival and productivity of these population areas for CC Chinook salmon. This ESU will not reach viable status without additional habitat protection and restoration actions throughout the CC Chinook salmon geographic-area, specifically actions that preserve water resources (e.g., streamflow, etc.) during the fall and spring, and limit overall water diversions in sensitive population areas. We conclude that the risk to the species' persistence because of habitat destruction or modification has not changed significantly since the last 5-year review in 2016 (NMFS 2016b).

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

Harvest

1. Ocean Harvest

Very limited data exist on the harvest of CC Chinook salmon. Freshwater fishery impacts on CC Chinook salmon are likely low because retention of Chinook is prohibited. For ocean fisheries, the Klamath River fall Chinook (KRFC) age-4 ocean harvest rate is used as a fishery management proxy to limit harvest impacts on CC Chinook salmon. The CC Chinook salmon ocean fishery conservation objective is a maximum KRFC age-4 ocean harvest rate of 16 percent (NMFS 2024).

The KRFC age-4 ocean harvest rate fell sharply from its average value of 44 percent over the 1981–1990 period. From 1991 to 1999, the harvest rates declined by 75 percent when compared to the previous 10 years (NMFS 2000; PFMC 2022). The CC Chinook consultation standard (i.e., maximum KRFC age-4 ocean harvest rate of 16 percent) was established in 2000. The average KRFC age-4 ocean harvest rate from 2001 to 2014 was 14 percent. Since the last 5-year review (years 2015 to 2022), harvest rates have averaged 23 percent; exceeding the consultation standard in six out of 8 years (PFMC 2023). NMFS reinitiated consultation on the effects of the ocean salmon fisheries on CC Chinook salmon in 2022 and in 2023 because the ocean fisheries had exceeded the conservation objective. In 2023, the Pacific Fishery Management Council (PFMC) adopted a management framework to ensure that the ocean salmon fisheries were managed consistent with the consultation standard for CC Chinook salmon. This framework includes management tools (e.g., conservative pre-season planning, catch limits for the fishery, and in-season management) designed to keep ocean harvest rates of age-4 KRFC (and thus impacts on CC Chinook salmon) under 16 percent (NMFS 2024). In February of 2024, NMFS issued a biological opinion analyzing the effects of the ocean salmon fisheries on CC Chinook salmon including the conservation objective and the management framework described above. The opinion determined that fisheries managed consistent with the conservation objective and the management framework are not likely to jeopardize the continued existence of CC Chinook salmon.

In summary, the recent increases in the KRFC age-4 ocean harvest rate suggests that the level of ocean fishery impacts on CC Chinook salmon has likely increased since the 2016 5-year review (NMFS 2016b). However, the recent management framework adopted by NMFS and the PFMC should ensure that fisheries remain within the conservation objective for CC Chinook salmon going forward.

2. Indirect mortality from catch and release of Chinook salmon

Commercial and recreational salmon fisheries occurring off the coasts of northern California and southern Oregon may incidentally encounter CC Chinook salmon. Chinook salmon may be released from these fisheries when retention of Chinook salmon is prohibited (i.e., fisheries targeting coho salmon off the coast of Oregon), retention of unmarked Chinook salmon is prohibited (i.e., mark-selective fisheries where Chinook salmon with an intact adipose fin must be released), and when they are undersized (i.e., regulations prohibit retention of Chinook salmon under a specific size). In these cases, indirect mortality of CC Chinook salmon may occur as a result of the impacts of being caught and released. Estimated rates of mortality for Chinook salmon released in ocean fisheries range from approximately 14 to 26 percent (of the fish released) depending on fish size, fishery, method, and location (Salmon Modeling and Analysis Workgroup 2023). The actual impact to CC Chinook salmon from catch and release is currently unknown but limits on the harvest of other salmon likely keep the impact to low levels.

Fisheries also can indirectly reduce diversity of life history strategies and alter the population structure, especially in small populations. There is a minimum size limit for harvest of Chinook salmon off the California coast, and older Chinook salmon can be removed from the population at a disproportionately higher rate. Over time this selective pressure can lead to a predominance of Chinook salmon spawning at a younger age, which could reduce the resiliency of a population to environmental variability. This population structure and life history effect could be reduced for CC Chinook salmon if annual exploitation rates are presumably lower than on targeted stocks such as KRFC. However, adequate information is unavailable to determine the life history effect on CC Chinook salmon due to current exploitation rates.

3. Freshwater Sport Fishing – Central and North Coast River Closures

The 2022-2023 California State Sport Fishing Regulations allow retention of hatchery steelhead in some streams critical for CC Chinook salmon recovery. For Chinook salmon the regulations allow for a catch and release fishery in the Russian and Eel Rivers; however, post hook and line mortality and associated reductions to spawning success are uncertain. Recreational fishing on the Eel River and Russian River can be high during the steelhead angling season, and anglers are likely to catch Chinook salmon at a higher frequency if targeted during low-flow periods, particularly when there is overlap with the steelhead run and/or Chinook salmon angling opportunities are accessible. Poaching and illegal retention is a threat in some populations.

During the 2015-16 freshwater sport fishing season, the California Fish and Game Commission decreased this threat by establishing low-flow closures in Marin, Sonoma, and Mendocino counties, further protecting listed salmonids (CC Chinook salmon, Central California Coast (CCC) steelhead, Northern California (NC) steelhead, and Central California Coast coho salmon) in 18 rivers (including the Russian, Garcia, Navarro, Gualala, Big, Noyo, Ten Mile, and Albion rivers) and streams that are open to steelhead fishing. However, much controversy still exists over these recent low-flow angling closure regulations. CDFW and NMFS continue to successfully defend the adequacy of low-flows closure regulations as the Fish and Game Commission denied a regulation change petition aimed to reverse these new protective angling regulations. In 2022, CDFW extended the low-flow closure season from September 1 through April 30 and closed all salmon fishing except for catch and release of Chinook salmon by federally recognized tribes in response to extreme drought conditions and declining salmonid returns (CDFW 2022). These actions further protect CC Chinook salmon and other species of salmonids during prolonged dry periods. However, CC Chinook salmon can be incidentally captured and harmed in catch-and-release steelhead fisheries.

The Eel River is another area of concern regarding freshwater sport fishing activities that threaten the recovery of CC Chinook salmon. Currently, the Eel River does have low-flow closures in strategic locations throughout the watershed; however, much concern exists over the adequacy of those low-flow thresholds. CC Chinook salmon can be harmed and killed during the catch-and-release fishery in the lower Eel River, which attracts hundreds, if not thousands, of anglers every season to target salmonids. Currently, sport fishing in the mainstem Eel River is subject to a low-flow fishing closure whenever the gage at Scotia is recording flows less than 350 cubic feet per second.

Additionally, proper species identification, handling and release techniques, when incidental capture of CC Chinook salmon occurs, is critical to reduce the likelihood of mortality and ensures CC Chinook salmon adult survival. An outreach campaign in the Russian, Garcia, Mad Rivers continues to be implemented and improved to raise angler awareness with informational press releases, fliers, and species identification signs at popular angler access points. Other efforts to improve angler conservation awareness and handling and release skills can be found in NMFS's *Scaling Back Your Impact: Best Practices for Inland Fishing* (https://media.fisheries.noaa.gov/2021-01/scaling-back-your-impact-catch-and-release.pdf*)* catch and release brochure.

4. Illegal Harvest

The extent of illegal harvest of CC Chinook salmon by poachers is currently unknown. Anecdotal reports and several observations of poaching equipment occur in various watersheds within the CC Chinook salmon ESU; particularly, within the Mendocino Coast, Eel River, and Mad River. Since the previous 5-year review of this ESU, NMFS has continued work with local partners on outreach initiatives to reduce poaching incidents within the ESU and aid law enforcement. These outreach efforts also promote reporting of poaching and other illegal activities, and support angler reporting efforts that assist with freshwater fisheries management. Following the Garcia River Anti-Poaching Resolution (Manchester-Point Arena Band of Pomo Indians 2015) and outreach campaign, reports of poaching in the Garcia River has been significantly reduced (CDFW, personcal communication 2020). NMFS expects that freshwater poaching occurs throughout the CC Chinook salmon ESU, and where poaching occurs frequently, losing several adult fish may continue to significantly impact population productivity and genetic diversity in specific watersheds where current abundance is below the "high risk" threshold.

Scientific Research and Monitoring

Take under ESA sections 10(a)(1)(A) and 4(d) for scientific research and monitoring for CC Chinook salmon 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 (i.e., lethal take allowed under permits NMFS issues) associated with scientific research and monitoring are generally capped at 0.5 percent of the total estimated abundance for an ESU. As a result, the mortality levels that research causes are very low. In addition, the effects research has on CC Chinook salmon are spread out over various reaches, tributaries, and areas across the CC Chinook salmon range, and thus no area or population is likely to experience a disproportionate amount of loss. Therefore, the research program 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 CC Chinook salmon.

The majority of the research 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, beach seines, fyke nets, minnow traps, weirs, and hand or dip netting, with smaller numbers collected as a result of other seines, trawling, hook and line sampling, and those intentionally sacrificed. Adult take has primarily been (and is expected to continue to be) capture via weirs or fish ladders, hook and line angling, with smaller numbers captured via trawls or hand or dip nets, and getting unintentionally captured by screw traps, seining, and other methods that target juveniles. Database records (NMFS APPS database; https://apps.nmfs.noaa.gov/) show that mortality rates are typically less than one percent for screw traps and less than three percent for backpack electrofishing. Unintentional mortality rates from seining, hand or hoop netting, fyke nets, minnow traps, weirs, and hook and line methods are also limited to no more than three percent. Also, a small number of adult fish may die as an unintended result of research because of interactions with trawl sampling equipment. The total amount of take that actually occurred from 2015 through 2019 decreased (by 32 percent in total, and by 13 percent for lethal take) compared to reported take from 2010 through 2014.

Overall, research impacts remain minimal and geographically well distributed throughout the North-Central California Coast. 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 changed little since the last 5-year review (NMFS 2016b), and remains low.

Listing Factor B: Conclusion

Information available since the last 5-year review indicates that the risk to the CC Chinook ESU due to harvest impacts has increased slightly. Improved outreach may have decreased illegal harvest in CC Chinook salmon freshwater sport fisheries; however, incidental impacts related to ocean harvest have increased substantially since the last 5-year review. Scientific research impacts have decreased for CC Chinook salmon compared to the last 5-year review. Due to the small number of individuals affected relative to the species' abundances and the dispersed nature of research activities, the impacts from these sources of mortality are not considered to be a major limiting factor for this ESU. Therefore, we conclude that the risk to the species' persistence because of overutilization due to harvest or research remains low.

Listing Factor C: Disease and Predation

Disease

The potential of disease outbreaks, due to introductions and straying of out-of-basin and other non-native fishes, are less likely than at the time of listing due to implementation of CDFW policies prohibiting inter-basin transfers. Therefore, wild populations of CC Chinook salmon are at less of a risk of disease outbreaks from a hatchery fish than they were previously. While there are no remaining CC Chinook salmon hatcheries, hatchery programs for CCC steelhead and CCC Coho Salmon (Russian River) and NC steelhead (Mad River) are in operation, where CC Chinook salmon exist. The threat of disease has been reduced at the Mad River Fish Hatchery by the use of well water, ultraviolet treatment of recirculated water and mandatory disease check of juveniles before release. NMFS has recently accepted an HGMP for the Mad River Fish Hatchery as sufficient. Questions remain on the status and disease control in the Russian River. Habitat conditions, such as low-flows and high temperatures, continue to exacerbate susceptibility to both disease and predation through increased physiological stress and physical injury throughout much of the ESU. These conditions may be exacerbated by releases from reservoirs (primarily Lake Pillsbury in the Upper Eel, and Lake Sonoma and Lake Mendocino in the Russian River) when water storage is low (e.g., during drought conditions). There is no information regarding how low storage in these reservoirs influences disease outbreaks within either population; nevertheless, the potential exists as noted in other watersheds (e.g., Klamath basin) and, therefore, poses a threat to these populations as drought conditions continue.

Predation

1. Fish Predation

Introductions of non-native species and habitat modifications have resulted in increased predator populations and predator success rates in this ESU. Adult and juvenile CC Chinook salmon encounter many natural predators, and the resultant loss in abundance and productivity is likely one of myriad stressors preventing the species from attaining population viability. Interactions between multiple stressors such as Sacramento pikeminnow (*Ptychocheilus grandis*) and smallmouth bass (*Micropterus dolomieu*) predation at small diversion dams and other altered habitat can also dramatically impact listed species (Sabal 2014). Sabal found that predation hotspots exist and estimated that striped bass consumption of out-migrating juvenile Chinook salmon to be between 10-29 percent when located in altered habitats (instream diversions). This research highlights the importance of examining the impacts of multiple stressors on ESA listed species.

The non-native Sacramento pikeminnow (*Ptychocheilus grandis*) is a large piscivorous fish that was introduced into Lake Pillsbury (upper mainstem Eel River) around 1979 and has since expanded its distribution throughout most of the Eel River basin (SEC 1998, Brown 1990, Brown and Moyle 1997, Harvey et al. 2002, Kinziger et al. 2014). Pikeminnow occur at very high densities in many parts of the watershed (White and Harvey 2001, Higgins 2020, PG&E 2020) and have the potential to fundamentally alter the aquatic ecosystem and negatively impact many native species (Stillwater and Wiyot 2020). Various studies indicate that pikeminnow compete with, prey on, or alter behavior of juvenile salmonids, lampreys, and other native fishes in the Eel River basin (Brown and Moyle 1997, White and Harvey 2001, Reese and Harvey 2002, Nakamoto and Harvey 2003, Stillwater and Wiyot 2020).

Since 2016, several investigations regarding Sacramento pikeminnow distribution and trends throughout the Eel River have occurred. In 2016, Sacramento pikeminnow were discovered in the North Fork Eel River by Patrick Higgins of the Eel River Recovery Project, prompting subsequent monitoring and suppression efforts by the BLM (Moloney and Ruddy 2017). Beginning in 2019, the Wiyot Tribe partnered with Stillwater Sciences to investigate population monitoring and suppression techniques in the South Fork Eel River, where boat-based electrofishing methods prevailed at being the most effective method tested thus far (Stillwater and Wiyot 2020).

Pacific Gas & Electric (PG&E) is required by NMFS' 2002 Potter Valley Project Biological Opinion (NMFS 2002) to implement a Sacramento pikeminnow suppression program targeting the project's infrastructure. Since 2017, has PG&E worked closely with NMFS in developing and implementing new suppression techniques and monitoring protocols. This expanded efforts into Lake Pillsbury and now include the use of boat electrofishing and mark and recapture techniques. These efforts have been significantly more effective than past efforts, but remain in the early stages of development. Various species of bass have been observed by PG&E in recent years, occupying areas near the Cape Horn Dam fish ladder entrance.

Hatchery-associated impacts to CC Chinook salmon include the large volume, timing, and release locations of Russian River hatchery steelhead. Historically, predation by the larger Russian River hatchery released steelhead smolts threaten smaller naturally produced listed CC Chinook salmon, CCC steelhead and CCC coho salmon (CDFW and USACE 2021). The Hatchery and Genetic Management Plan for the Russian River Steelhead Programs (CDFW and USACE 2021) has addressed this issue by reducing the size and location of smolts released. Additionally, a study conducted by Sonoma Water identified low survival of rearing migrating coho salmon in the mainstem between Dry Creek and their diversion operations at Wohler inflatable dam, which has converted riffle and pool habitat to slow backwater, enhancing the production of native and invasive predatory fish species. Similarly, to coho salmon, it is likely that high predation rates are occurring on juvenile CC Chinook salmon in this area, which could be further suppressing production in the Russian River population.

2. Marine Mammal Predation

Recent research over the past 5 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 Ocean over the past few decades (Chasco et al. 2017) and are known to selectively prey on Chinook salmon (Hanson et al. 2021). On a Pacific coast-wide scale, converting juvenile Chinook salmon into adult equivalents, Chasco et al. (2017) estimated that by 2015, seals and sea lions (pinnipeds) consumed double the amount of Chinook salmon taken by Southern Resident killer whales and six times the combined commercial and recreational catches.

The three main 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 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 (Marshall et al. 2016; Chasco et al. 2017; Thomas et al. 2017).

• California Sea Lion (United States Stock):

The current population size of California sea lions is 257,606 (Carretta 2019). The stock is estimated to be approximately 40 percent above its maximum net productivity level (183,481 animals), and it is considered within the range of its optimum sustainable population (OSP) size (Carretta 2019). There are no qualitative or quantitative estimates (number of seasonal animals) of California sea lions in California estuaries/rivers.

• Steller Sea Lion (Eastern United States Stock):

The current population size of Steller sea lions is 71,562 (52,139 non-pups and 19,423 pups) (Muto et al. 2019). Muto et al. (2017) conclude that the eastern stock of Steller sea lions is likely within its OSP range; however, NMFS has made no determination of its status relative to OSP.

In California, the current population size of Steller sea lions (California rookery sites) is 3,120 non-pups, and 936 pups (Muto et al. 2019; Muto et al. 2020). There are no qualitative or quantitative estimates (number of seasonal animals) of Steller sea lions in California estuaries/rivers.

• Harbor Seals (California Stock):

The current population size of the California stock of mainland and offshore islands haul out sites is 30,968 (Carretta 2019), with a minimum population size estimated at 27,348 (Carretta 2019). This stock's status relative to OSP is unknown.

In California, these species of pinnipeds occur annually and/or seasonally in most Chinook salmon rivers; however, there are limited qualitative or quantitative assessments of pinnipeds (i.e., number of seasonal animals) in these watersheds. In the Columbia Basin, 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 (Wargo Rub et al. 2019; Sorel et al. 2021). Whether increasing sea lion populations in California are associated with decreased survival of any ESA-listed salmonid ESU or DPS through estuarine and freshwater migration corridors in the state is currently unknown, as there have not been assessments of predation on Pacific salmon and steelhead populations in California estuaries/rivers to date. Most authors have focused research on Chinook salmon because they have the highest energy value for predators (O'Neill et al. 2014). However, some study authors have found that pinnipeds like harbor seals can have a significant impact on other species of salmon (Thomas et al. 2017) and steelhead (Moore et al. 2021) through the consumption of outmigrating juveniles. Harbor seal predation data specific to California is not currently available, so whether predation of outmigrating juveniles is a threat to ESA-listed salmonids in California rivers and estuaries is currently unknown.

Invasive Species

Aquatic invasive species (AIS), are organisms (plants, animals, or pathogens) that impact the diversity or abundance of native species, the ecological stability of infested waters, and/or the commercial, agricultural, aquaculture or recreational activities dependent on such waters. The myriad pathways by which AIS can enter and are transported to coastal marine, estuarine, and riverine areas pose a significant management challenge. In coastal marine and fresh water environments, AIS have been shown to have major negative effects on the receiving communities where they often outcompete native species, reduce species diversity, change community structure, reduce productivity and disrupt food web function by altering energy flow among trophic levels (Cohen and Carlton 1995, Cohen and Carlton 1998, Ruiz et al. 2000, Stachowicz and Byrnes 2006). There are multiple mechanisms of impact that directly affect salmonids, such as predation and infection (disease and parasitism), and indirectly such as competition, hybridization, and habitat alterations (Mack et al. 2000, Simberloff et al. 2005).

We need to understand the role of AIS in the decline of threatened and endangered fish across multiple scales (i.e., individual populations, communities, and ecosystem process) in order to effectively manage and recover these species and systems in the face of global climate change and the full suite of stressors. In California, approximately half of the freshwater species, which include aquatic invasive plants, animals, and pathogens, are introduced; and as many as 40 introduced species may be present in individual watersheds. Despite the abundance of AIS (plants and invertebrates' taxa), there is limited information to assess their impacts on aquatic ecosystems, thus the associated implications for habitats occupied by threatened and endangered salmonids is difficult to determine (Sanderson et al. 2009). More studies are needed to specifically investigate the impacts of AIS on ESA-listed salmonid populations, their designated critical habitat, and species recovery.

NMFS recognizes that AIS pose potential risk and may reduce the number of juvenile salmonids before they transition to adulthood. The cumulative AIS impacts are potentially quite large and should be considered in conjunction with the more commonly addressed impacts on salmonids. In areas where AIS are already established, control and management to prevent their further spread and lessen their impacts on native ecosystems will reduce the risk to salmonids and aid their recovery.

Listing Factor C: Conclusion

There is no new information available since listing or the last 5-year review to indicate whether there is an increase in the level of non-native fish species (e.g., Sacramento pikeminnow) and pinniped predation on CC Chinook salmon, or that disease impacts are more than a minor factor in the present depressed state of the ESU. However, emerging marine mammal predation science indicates the predation rates are on the rise on some salmonid populations in the northwest. Therefore, proper evaluation of marine mammal predation rates on specific CC Chinook salmon populations should be conducted to inform population level impacts associated with this developing concern.

Listing Factor D: Inadequacy of Existing 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, such as hydro-systems, as well as harvest impacts. For this 5-year review, we focus our analysis on regulatory mechanisms for **Habitat** and for **Harvest** that have improved for CC Chinook salmon, as well as those that continue to cause concern in terms of providing adequate protection for CC Chinook salmon.

1. Habitat

Habitat concerns are described throughout Listing Factor A as having either a system-wide influence, or more localized influence, on the populations and Diversity Strata that comprise the species. The habitat conditions across all habitat components (tributaries, mainstems, estuary, and marine) considered important to recover the listed CC Chinook salmon 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 based in large degree by 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 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, and upscaling and acceleration of far-reaching, multilevel, and cross-sectoral climate mitigation efforts will likely help further reduce future climate-related risks (IPCC 2014; IPCC 2018). These findings suggest that current regulatory mechanisms, both in U.S. and internationally, are not currently adequate to address the rate at which climate change is negatively impacting habitat conditions for many ESA-listed salmon and steelhead.

Regulatory Mechanisms Resulting in Adequate or Improved Protection

New information available since the last status review indicates that the adequacy of some regulatory mechanisms has improved and has increased protection of CC Chinook salmon. These include federal and state regulatory mechanisms.

1. Endangered Species Act Section 7 Biological Opinion and Federal Power Act Potter Valley Project Eel River, CA: Blockwater Releases

In 2002, NMFS issued a jeopardy biological opinion on PG&E's Potter Valley Project. The Potter Valley Project on the Eel River is a set of hydroelectric facilities that includes two large dams (Scott and Cape Horn), water-diversion facilities, and a powerhouse. The project involves an inter-basin transfer that stores winter runoff from the upper Eel River and diverts much of that water to the Russian River to generate hydroelectric power and meet contract water demands. Scott Dam, which creates Lake Pillsbury, is a complete barrier to native fish species, preventing access to high-value habitat for federally Endangered Species Act (ESA)-listed anadromous salmonids. In efforts to avoid the likelihood of jeopardizing the continued existence of CC Chinook salmon, Southern Oregon-Northern California (SONCC) coho salmon, and NC steelhead, NMFS included a suite of reasonable and prudent alternatives (RPAs) in their 2002 biological opinion (NMFS 2002). These RPAs are modifications of the proposed action designed to provide improved conditions for various salmonid life cycles in the Eel River.

Between 2016-2024, blockwater has been used in various ways to augment low fall flows for adult CC Chinook salmon and aid summer rearing conditions for NC steelhead. However, NMFS believe the most effective use of both these RPAs is in conjunction with each other to augment the spring recession, while mimicking natural environmental cues (flow and temperature). Therefore, spring release strategies are primarily designed to encourage the timely emigration of juvenile Chinook salmon. Each spring release strategy presented different water supply constraints requiring different release strategies. These strategies range from temperature dependent cues, to sequential pulse releases, to mimicking a spring freshet. Although, juvenile Chinook salmon are often the target species and life stage within the Potter Valley Project area, many other salmonid species benefit from this action as they enter the mainstem Eel River from tributaries downstream of Cape Horn Dam (e.g., Chinook salmon and steelhead from Tomki Creek; Chinook salmon, coho salmon, and steelhead from Outlet Creek). These other benefits include improved flow conditions for migration (upstream and downstream), increased foraging opportunities, and possibly a higher probability of juvenile salmonids avoiding predators as they emigrate to the lower Eel River and estuary. Based on preliminary data from ongoing monitoring at the time of this 5-year review, these releases appear to have been successful in meeting their intended objectives.

2. Continued implementation of the Potter Valley Project Drought Working Group (DWG)

Due to a higher frequency in extreme drought conditions, Potter Valley Project interested parties comprised of resource agencies, tribes, municipalities, and agricultural interests have successfully worked together on several occasions to make formal variance requests to FERC to achieve beneficial changes to existing project operations due to limited water availability. Without these collaborative variance requests and FERC approvals, Lake Pillsbury storage conditions would have reached inoperable conditions (dead-pool) several times, resulting in the inability to release adequate water for environmental purposes, particularly for Upper Eel River CC Chinook salmon and NC steelhead.

3. Medicinal and Adult-Use Cannabis Regulation and Safety Act

In 2015, the California legislature established the first state-wide regulatory systems for medical cannabis via the Medical Marijuana Regulation and Safety Act. After Proposition 64 passed in 2016, allowing recreational cannabis use for adults (the Adult Use Marijuana Act), the California legislature consolidated the provisions of both acts into the Medicinal and Adult-Use Cannabis Regulation and Safety Act (MAUCRSA) in 2017. The MAUCRSA established several state-wide permitting programs for the cannabis industry, three of which pertain specifically to minimizing environmental impacts arising from outdoor cannabis cultivation. These programs are implemented by the CDFW, State Water Resources Control Board, and the Regional Water Quality Control Boards.

CDFW is responsible for ensuring cannabis cultivation does not adversely impact fish and wildlife resources. It accomplishes this task through Lake and Streambed Alteration Agreement permitting and enforcing applicable Fish and Game Code and California Penal Code violations. The California State Water Resources Control Board (State Board) and Regional Water Quality Control Boards (Regional Boards) also regulate and permit various aspects of the cultivation operation related to water diversion and pollutant discharge. The State Board's Cannabis Cultivation Policy (State of California State Water Resource Control 2019) addresses water quality impacts through various regulations carried out by the Regional Boards, including those setting riparian setback and slope limitations, road development and stream crossing requirements, and fertilizer and pesticide application and management protocols. The State Board addresses impacts to surface water quantity through both numeric and narrative instream flow requirements, the most pertinent being restrictions on the surface flow diversion season (no diversions between April 1 and October 31) and mandatory bypass flow requirements at each diversion point.

The regulatory and permitting program outlines a comprehensive approach to minimize cannabis cultivation impacts on surface water quality and quantity, including those affecting salmon and steelhead. However, most cannabis cultivators seeking permitting from CDFW and the State Board propose using groundwater pumping as their water source, thus avoiding the season and bypass flow requirements stipulated for surface water diversions. An unknown, but likely large number of these wells are located near streams and rivers since shallow groundwater depths decrease well drilling costs, and groundwater depths typically increase proportionally with distance from a stream. These wells may be depleting hydraulically connected streamflow and significantly impairing steelhead instream habitat, especially during summer months when flows are lowest and irrigation demand highest. This groundwater-surface water relationship largely goes unrecognized and unanalyzed during local and state permitting processes. Another factor that limits the State's environmental protection efforts is the number of illegal/unregulated cultivation operations that remain on the landscape. Many growers object to the cost associated with permitting a "legal" grow operation, which may incentivize growers to avoid state regulation. Appreciable improvements in instream habitat quality for salmon and steelhead and other native aquatic resources may not be realized unless industry oversight is improved and expanded.

4. Frost Protection Regulations

Water extractions from streams or hydraulically connected groundwater, specifically those aimed at protecting grapevines from frost damage, can strand newly emerged salmon fry during the spring period. On September 20, 2011, the State Water Board adopted Frost Protection Regulations for the Russian River Watershed. The regulation seeks to minimize harmful stream stage changes by controlling and coordinating "frost protection" diversions. The use of water for frost protection is widespread in the basin. Particularly in spring seasons with many frost events, this regulation is likely to improve fry survival in the mainstem and some larger tributaries where Chinook salmon spawn and rear. Starting with the 2015 frost protection season (March 15 through May 15) those regulations went into effect, and anyone diverting water for frost protection must participate in a Water Demand Management Program. Generally, coho salmon populations are absent in the upper Russian River area of Mendocino County, therefore, frost protection actions in Sonoma County are more important for the protection of Chinook salmon. Agricultural producers in the Sonoma County portion of the Russian River watershed that participate in the frost protection program are registered with the North Coast Water Coalition. This program employs stream gauges to monitor fluctuations in stream flow elevation (referred to as stage changes) resulting from water diversions. These diversions could potentially lead to the stranding of juvenile salmonids due to rapid dewatering. Since 2015, risk assessment results have been reported for various focus areas where approximately 30 stream gauges monitor frost water diversions in Russian River watershed. Risk assessment reporting since 2015 indicates that there are a relatively low number of stage elevation reductions that would have the potential to strand salmonid juveniles or fry. The number of and amount of direct diversions for frost protection activities largely depends on water year type with drought year or dry spring years having more potential for diversions that may result in strandings.

Frost assessment reports for the Sonoma County North Coast Water Coalition suggest that grape growers that are not in the program can pose an additional risk because it is difficult to identify these diverters and remediate their diversion activities. Also, recharge for pond refilling can sometimes be difficult to assess and needs to be further evaluated to understand how ponds are managed for frost (O'Conner Envirormental Inc. 2020). Many agricultural producers are now using wind as a means to reduce frost damage along with improved weather forecasting to reduce the time frost protection is used (C. Munselle, personal communication 2021). Future efforts to reduce diversions for frost protection should focus on increased use of wind and improvements in pond refilling management.

5. CA Forest Practices/CA Anadromous Salmon Protection

At the time of salmon and steelhead listings, the State Forest Practice Rules were found to inadequately protect salmonids. Many of the identified inadequacies have been ameliorated through regulation changes by the State Board of Forestry. The most notable rule changes with input from NMFS, CDFW, and other State agencies are the 2010 Anadromous Salmonid Protection Rules and the 2012 Road Rules. These rules have resulted in expanded stream-buffer widths, less damaging road and harvest techniques, and limits on riparian harvesting that will collectively improve instream and riparian habitat and function over the long-term. Additionally, some private timber companies are actively restoring damaged aquatic and upslope habitat, by increasing instream large wood volume or abating upslope erosion sources. The State Forest Practice Rules have also made additional changes to the cumulative watershed effects analysis of proposed timber harvest practices. These Board of Forestry rules (applies to northern/central portion of the ESU), that provide additional no-cut buffer protections to certain Class II-Standard watercourses. However, since the 2017 wildfires throughout the ESU, salvage logging of burned trees has substantially increased which poses a threat to Chinook salmon spawning and rearing habitats. Since salvage logging is a ministerial action not requiring review or allowing modification to timber operations, harvest of burned but otherwise healthy trees has increased substantially in Sonoma and Mendocino counties impacting numerous populations in several diversity strata. Given the recent increase in the level of wildfires, these rules remain inadequate to protect Chinook salmon.

6. Flood Protection Practices

In recent decades, Federal and local entities have recognized the issues caused by past flood control practices and are acting to avoid perpetuating these problems into the future. Positive efforts include implementing designs that integrate fluvial geomorphology with hydraulic engineering, remove hydraulic constrictions, restore floodplains, and provide fish passage. In addition, climate change and the associated threats of sea level rise and more severe and frequent flooding has again made flood control a priority for many local governments and private citizens. This renewed focus on flood control can be seen as a positive or negative trend, depending on the approach taken. Rebuilding flood control structures in-kind will perpetuate ongoing habitat impacts. However, applying current knowledge regarding the resiliency of natural ecosystems to climate change and the ability of healthy ecosystems to support flood protection should integrate ecosystem considerations into flood control designs, potentially resulting in habitat restoration at a grand scale, and significantly improved flood risk management. To guide future flood control projects in a direction that results in improvements to both habitat and flood protection, increased regulatory oversight would be useful to ensure flood control projects are designed to achieve long-term hydraulic, geomorphic, and ecological sustainability. Resource agencies should play an active role in informing communities and local flood-control entities (through outreach and regulation) of how innovative flood control approaches can provide environmental benefits, long-term sustainability and cost-savings to flood protection efforts. Interagency review and coordination, and stakeholder involvement are likely to be integral to achieving these goals.

7. Habitat Focus Areas

The Russian River watershed (Central Coastal Diversity Stratum) was selected as the first Habitat Focus Area under NOAA’s Habitat Blueprint. This was an important step to increase the effectiveness of NOAA’s habitat conservation science and management efforts by targeting multiple habitat conservation objectives aimed to rebuild Russian River salmonids to sustainable levels through habitat protection and restoration. NOAA’s National Weather Service has improved frost, rainfall, and river forecasts in the Russian River watershed through advanced data collection and modeling for the purpose of improving streamflows by decreasing withdrawals from irrigation activities. NOAA’s Office of Oceanic and Atmospheric Research is continuing to work toward increasing community resiliency to flooding damage through improved planning and water management strategies.

Regulatory Mechanisms Resulting in Inadequate or Decreased Protection

We remain concerned about the adequacy of existing habitat regulatory mechanisms regarding water quality from excess sediment and toxicity, loss of habitat due to habitat conversions and access to floodplains, and the impacts of floodplain connectivity, flood storage/inundation, and hydrology. These include Federal and state regulatory mechanisms.

1. Clean Water Act

The Federal Clean Water Act addresses the development and implementation of water quality standards, the development of Total Maximum Daily Loads (TMDLs)[2], filling of wetlands, point source permitting, the regulation of stormwater, and other provisions related to protection of U.S. waters. The Clean Water Act is administered by the State of California with oversight by the U.S. Environmental Protection Agency. 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 California.

Each state has a water quality section 401 certification program that reviews projects that will discharge dredged or fill materials into waters of the U.S. 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, 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[3] that fail to meet water quality standards in repeated testing. These constituents may be pesticides such as dieldrin which is regulated under the Federal Insecticide, Fungicide and Rodenticide Act, industrial chemicals such as polychlorinated biphenyls (PCBs) regulated under the Toxic

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[2] 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.

[3] 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.

Substances Control Act,[4] or physical measures of water such as temperature for which numeric water quality standards have been developed. There are numerous toxicants that have yet to be addressed in a TMDL.

2. Stormwater Runoff

Stormwater runoff is the primary way that non-point source pollution is conveyed to waterways, where it may affect salmonids and their habitat. Pollutants in stormwater are reflective of their source areas and land use. Urbanized areas contribute general-use pesticides sold in stores and legacy pesticides from their former (often agricultural) land uses, nutrients from lawn and garden care, and elevated levels of suspended sediment and turbidity from land-disturbing activities. Stormwater runoff can also carry geologic signatures from their source areas, for example, elevated selenium from the southern Central Valley in California, or elevated levels of nickel around the San Francisco Bay. Roads and streets contribute additional stormwater contaminants such as Polycyclic Aromatic Hydrocarbons (PAHs), oils and greases, various heavy metals such as copper and zinc, and other toxic substances such as tire particles (containing 6PPD-quinone). Fish embryos and larvae exposed to PAHs have been documented to experience adverse changes in heart physiology and morphology, including pericardial and/or yolk sac edema leading to heart failure or impaired swimming performance, even with only temporary exposure to low concentrations (Hicken et al. 2011, Brette et al. 2014, Incardona and Sholz 2017). Exposure of some PAHs to sunlight has been observed to increase toxicity to invertebrates (Pelletier et al. 1997, Swartz et al. 1997) and resulted in as little as 2 μg/L becoming toxic to calanoid copepods (Duesterloh et al. 2002). Impacts to phytoplankton and zooplankton communities have also been reported in the literature (Sibley et al. 2004, Bestari et al*.* 1998).

Heavy metals such as copper and zinc are also well-documented contaminants in storm water from roadways (CA DTSC 2021, Caltrans 2003a, 2003b, 2000) and have been shown to detrimentally affect salmonids and their habitat at very low, environmentally realistic levels. These low levels are noted to impact the resistance of fishes to disease, cause hyperactivity, impair respiration, disrupt osmoregulation and calcium levels and/or impact olfactory performance leading to disruption in critical fish behaviors at concentrations that are at, or just slightly above, ambient concentrations (Eisler 2000, Hecht et al., 2007).

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[4] The Toxic Substances Control Act (TSCA) of 1976 provides the U.S. Environmental Protection Agency with authority to require reporting, record-keeping and testing requirements, and restrictions relating to chemical substances and/or mixtures. Certain substances are generally excluded from TSCA, including, among others, food, drugs, cosmetics, and pesticides.

The tire particle associated 6PPD-quinone has only recently been identified as a source of mortality for salmon and steelhead, although it has been in use for many decades and may be responsible for observations of toxicity whose cause was previously listed as unknown. Tire-derived products used by agencies and municipalities, such as asphalt rubber paving, fill for overpass construction or surface area covers for porous walkways, paths and bike trails, may also contribute harmful chemicals to waterways (CA DTSC 2022). This contaminant is widely used by multiple tire manufacturers and the tire dust and shreds that produce it have been found to be ubiquitous where both rural and urban roadways drain into waterways (Sutton et al. 2019, Feist et al. 2017). Potential impact levels in a waterbody depend on roadway utilization (traffic density and average speeds) and road density (Feist et al. 2017, Peter et al. 2022) as well as the specific drainage patterns from the roadways. There is limited information available regarding impacts to Chinook salmon at this time. Symptoms of morbidity to juvenile Chinook salmon exposed to untreated urban storm water runoff containing 6PPD-quinone were noticeable within hours, and they did not recover when transferred to clean water (French et al. 2022). Levels of 6PPD-quinone that have been found in laboratory studies to cause impacts to Chinook or other salmonids are realistic and documented in the environment (Challis et al. 2021, Johannessen et al. 2022).

The highest concentration of chemicals harmful to instream habitats are expected to be associated with the point of discharge during and shortly after rainfall, particularly "first-flush" rain events after long antecedent dry periods. However, when road densities are high enough many contaminants exhibit transport-limited, rather than mass-limited, characteristics. This means the source of contaminants within the system is large enough that additional precipitation continues to mobilize the pollutants either by transporting that which was newly deposited on the roadway or that which was less mobile or more distant from the discharge point (Peter et al. 2022, 2020, Johannessen et al. 2022, Feist et al. 2017). In these cases, designated critical habitat has the potential to experience a temporary or permanent reduction in function and value as a result of exposure to untreated stormwater runoff, particularly near urban areas.

Fortunately, other recent literature has shown that the mortality impacts can be limited by infiltrating the road runoff through soil media containing organic matter which results in removal of contaminants (Fardel et al. 2020, Spromberg et al. 2016, McIntyre et al. 2015). Drainage systems that incorporate soil media for biofiltration of runoff are commonly included in new construction projects but are often lacking in existing infrastructure. Also, many redevelopment or routine maintenance projects in roadway or urban development settings do not require mitigation of this pollution source. Therefore, pollution from these roads and streets remains a concern for salmon and steelhead, as well as toxic compounds in stormwater runoff from other non-point sources.

3. Section 404 Fill Permitting

Another challenge to Clean Water Act implementation relates to the permitting of fill. Under the Clean Water Act, the federal government has a "no net wetland loss" policy. While well-intentioned, this policy has been largely ineffective at preserving the amount and, more importantly, the ecological functions of wetland habitat in the U.S. (Dahl and Stedman 2013). Additionally, application of the "no net wetland loss" policy can, in some cases, restrict restoration of impaired habitat by limiting or precluding placement of beneficial fill. For example, the USACE's implementation of this policy may impede placement of beneficial fill necessary to restore impaired wetlands or waters (e.g., such as occur in former on-channel quarry areas, channels subject to anthropogenically caused scour/degradation, where human-induced land subsidence requires fill for restoration purposes, etc.).

A variety of factors, including inadequate staffing, training, and in some cases regulatory limitations on land uses (e.g., agricultural activities) and policy direction, result in ineffective protection of aquatic habitats important to migrating, spawning, and rearing steelhead. The deficiencies are particularly acute during large-scale flooding events, such as those associated with El Niño conditions, which can put additional strain on federal and state agencies implementing the Clean Water Act Section 404 and 401 programs. For example, at the federal level, the USACE lacks a comprehensive and consistent process to address the cumulative effects of continued waterfront, riverine, coastal, and wetland development, and USACE guidelines do not identify a methodology for assessing specific impacts or cumulative impacts. The Clean Water Act is, therefore, not effectively protecting fishery resources, particularly regarding non-point sources of pollution and limitations of the "no wetland loss" policy. Leveraging existing state and federal authorities and partnerships will be critical to the protection of existing CC Chinook salmon habitat and restoration of impaired critical habitat.

4. Federal Insecticide, Fungicide and Rodenticide Act and Toxics

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) provides for federal regulation of pesticide distribution, sale, and use. All pesticides distributed or sold in the United States must be registered (licensed) by the EPA. Before the EPA may register a pesticide under FIFRA, the applicant must show, among other things, that using the pesticide according to specifications "will not generally cause unreasonable adverse effects on the environment." NMFS has performed a series of consultations on the effects of commonly applied chemical insecticides, herbicides, and fungicides which are authorized for use per Environmental Protection Agency label criteria on 28 west coast species of salmon and steelhead. Of these commonly applied chemical insecticides, herbicides, and fungicides, many have been determined to jeopardize the CC Chinook salmon ESU and adversely modify its critical habitat, and others have been found to adversely modify critical habitat for the CC Chinook salmon ESU, but not jeopardize the species. See Table 5 for a list of the substances that either jeopardize CC Chinook salmon and/or adversely modify their critical habitat.

Table 5. List of commonly applied chemical insecticides, herbicides, and fungicides that either jeopardize CC Chinook salmon and/or adversely modify their critical habitat.

Chemical Insecticides, Herbicides, Fungicides	Does it Jeopardize CC Chinook Salmon Species?	Does it Adversely Modify CC Chinook Salmon Critical Habitat?	Citation
2,4-D	Yes	No	NMFS 2015
Diflubenzuron	Yes	Yes	NMFS 2015
Fenbutatin oxide	Yes	Yes	NMFS 2015
Propargite	Yes	Yes	NMFS 2015
Oryzalin	Yes	Yes	NMFS 2012
Pendimethalin	Yes	Yes	NMFS 2012
Trifluralin	Yes	Yes	NMFS 2012
Naled	Yes	Yes	NMFS 2010
Phorate	Yes	Yes	NMFS 2010
Phosmet	Yes	Yes	NMFS 2010

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 42422); "Activities affecting this habitat include…wetland and floodplain alteration" (64 FR 50394).

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 California 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 2008, NMFS 2016c).

6. California's Sustainable Groundwater Management Act

California's Sustainable Groundwater Management Act (SGMA) was signed into law in January, 2015, during the height of the state's historic drought. SGMA required medium and high priority groundwater basins to form local Groundwater Sustainability Agencies (GSAs) by 2017, and develop and begin implementing a Groundwater Sustainability Plan (GSP) by 2022 that achieves sustainable groundwater conditions no later than 2042. Sustainability under the act is defined as avoiding six "undesirable results" caused by unsustainable groundwater management, one of which is "significant and unreasonable impacts to beneficial uses of surface water". Since many waterways overlying SGMA basins contain Federally designated critical habitat for ESA-listed salmonids, NMFS has actively participated as a stakeholder in many GSP development processes throughout the state by advising GSAs to consider and avoid streamflow depletion impacts to salmon and steelhead habitat. However, a provision in SGMA legislation allows each GSA to choose whether they wish to address any undesirable results occurring prior to January 1, 2015. To date, every GSA has interpreted that language as allowing streamflow depletion rates consistent with summer 2014 as an appropriate and legal management objective. This means that the threshold to take action on streamflow depletion only applies when streamflow depletion is *worse* than that seen during the depths of our recent historic drought, as 2014 was the third year in the driest 4-year stretch in California's recorded history (Hanak et al. 2016), with many detrimental consequences for salmon and steelhead individuals and habitat. To counter this approach, NMFS has commented consistently within every basin during the past 5 years of GSP development that proposed streamflow depletion thresholds consistent with historic drought conditions are likely to degrade salmonid migration, spawning, and rearing habitat and harm ESA-listed species.

Streamflow depletion is difficult to measure, and often requires a groundwater/surface water model for analysis, which the GSPs will develop within the first 5 years of plan implementation. One basin (Sonoma Creek) developed a "preliminary" model during GSP development that estimated groundwater pumping caused a streamflow depletion rate of 90 percent (as compared to a "no pumping" scenario) during summer/fall 2014, providing support for NMFS' concern about detrimental impacts to salmon and steelhead habitat. California's Department of Water Resources (DWR) is currently evaluating the submitted GSPs for consistency with the Act/regulations, with final determinations expected in early 2024. Given the lack of response by DWR to any of NMFS' attempts to directly raise this issue to date, NMFS is not confident that any GSA will be required to amend their GSP to thresholds that do not use the 2014 drought conditions as an acceptable objective.

Harvest

1. California Freshwater Fishing Regulations

The 2023-24 California State Sport Fishing Regulations allow catch and release or retention of steelhead in nearly all anadromous streams in California (CDFW 2023). Partial protection measures have been established by the California Fish and Game Commission to provide fishing opportunities while reducing threats to other non-targeted federally listed salmonids. These partial protection measures include low-flow closures in some watersheds within the ESU and DPS catch and release handling measures, reduced bag limits, limited fishing days, geographic limits, gear restrictions, and fishing prohibitions. Recreational angling is popular across all ESUs and DPS', yet its impact remains uncertain despite restrictions through modifications of the angling regulations. CDFW, in cooperation with NMFS, implemented measures that lowered the chance of incidental CC Chinook salmon catch and harvest during recreational freshwater fishing. Starting in 2015-16, CDFW amended California sport fishing regulations to include low-flow fishing closures (as mentioned above) along the Sonoma and Mendocino county coasts. As mentioned above, in 2022, CDFW extended the low-flow closure season from September 1 through April 30 and closed all salmon fishing except for catch and release of Chinook salmon by federally recognized tribes in response to extreme drought conditions and declining salmonid returns (CDFW 2023). These advancement in fishing regulations are intended to minimize over-exploitation of ESA protected adult steelhead when stream flows recede to a level where capture rates climb sharply, and should have a similar effect in lowering the inadvertent bycatch of CC Chinook salmon during the same low-flow conditions. However, bycatch of CC Chinook salmon by fishers targeting steelhead is still a concern during fall/winter baseflow conditions throughout the CC Chinook salmon ESU.

Recreational, commercial, and tribal fisheries can be managed in a way that protects listed salmon and steelhead and allows them to recover. The 4(d) rule does not prohibit the take of listed fish in fisheries if a fishery management agency develops a Fisheries Management and Evaluation Plan (FMEP) and NMFS approves it. If an FMEP is implemented accordingly, take of listed species in the fisheries will be covered under the ESA. The primary goal of the FMEP is to devise biologically based fishery management strategies that ensure the conservation and recovery of listed ESUs. Development and finalization of Fisheries Management Evaluation Plans for California are recommended to ensure proper fisheries management of sensitive stocks by establishing a more formal program to minimize the take of federally-listed salmonids.

Finally, species identification and proper handling and release techniques, when incidental capture of listed salmonids occurs, are critical to reduce the likelihood of injury and/or death. Improving angling outreach remains a priority to educate anglers on handling techniques, the reporting of poaching and other illegal activities, and their contributions to species population monitoring. Other efforts to improve angler conservation awareness and handling and release skills can be found in NMFS's *Scaling Back Your Impact: Best Practices for Inland Fishing*.[5]

2. Pacific Fishery Management Council Harvest Management

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 (PFMC 2022), it currently contains fishery management objectives only for

[5] https://media.fisheries.noaa.gov/2021-01/scaling-back-your-impact-catch-and-release.pdf and https://www.fisheries.noaa.gov/west-coast/recreational-fishing/recreational-fisheries-west-coast

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 MSA, 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 (Quan 2024). Ocean fishery management actions for CC Chinook salmon beyond those already in place are not necessary.

Listing Factor D: Conclusion

The Final Coastal Multispecies Recovery Plan (NMFS 2016a) and the previous 5-year review identified inadequate regulatory mechanisms as contributing substantially to the decline of the CC Chinook salmon ESU. Based on the improvements noted above, we conclude that the risk to the species' persistence because of the adequacy of existing regulatory mechanisms has decreased slightly. However, despite improvement in the adequacy of some regulatory mechanisms within the ESU, a number of concerns remain regarding existing regulatory mechanisms affecting floodplain development and water quality, including:

- Lack of implementation and enforcement of existing regulations, including the Clean Water Act's "no net wetland loss" policy. Improving wetland protection within the CC Chinook salmon ESU will likely be critical in future recovery efforts.

- USACE continues to lack a comprehensive and consistent process to address the cumulative effects of the continued development of waterfront, riverine, coastal, and wetland properties.

- NFIP implementation in California may also be incrementally and permanently diminishing floodplain habitat form and function to the detriment of CC Chinook salmon.

- Lack of regulations or mitigation regarding the infiltration of road runoff through soil media containing organic matter to remove road-runoff contaminants for existing infrastructure, and many redevelopment or routine maintenance projects in roadway or urban development settings.

Recommended Future Actions Over the Next 5 Years Toward Achieving Population Viability

The greatest opportunities to advance recovery of CC Chinook in the Central Coastal Diversity Stratum are the following:

1. Habitat

- Improve regulations to minimize or mitigate road-runoff containments in existing infrastructure, re-development, and routine maintenance projects.

- SGMA: Continue NMFS engagement as a stakeholder in GSP implementation.

- SGMA: NMFS should ensure they have the staff expertise necessary to evaluate groundwater/surface water hydrologic models to ensure they are properly developed, and use those models to quantify streamflow depletion impacts resulting from groundwater management activities.

- SGMA: NMFS should maintain coordination with CDFW, the State Water Resources Control Board, and environmental organizations whose goals and objectives for minimizing streamflow depletion impact ESA-listed salmon and steelhead.

- SGMA: GSAs should be required to use streamflow depletion sustainable management criteria that avoid adversely impacting salmon/steelhead migration, spawning, and rearing habitat, and do not harm ESA-listed species. Criteria consistent with historic drought conditions (i.e., summer/fall 2014), are likely to degrade salmon and steelhead habitat and harm these species.

- Increase the use of wind turbines and improvements in pond-refilling management for frost protection.

2. Harvest

- Develop FMEPs that (1) incorporate delisting criteria; (2) determine impacts of fisheries management in terms of VSP parameters; (3) do not limit the attainment of population-specific criteria; (4) annually estimate the commercial and recreational fisheries bycatch and mortality rate; (5) are specifically designed to monitor and track catch and mortality of wild and hatchery salmon and steelhead stemming from recreational fishing in freshwater and the marine habitats; and (6) provide for adaptive management options as needed to ensure actual fisheries impacts do not exceed those consistent with recovery goals.

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

Climate Change

Major ecological realignments are already occurring in response to climate change (IPCC 2022). Long-term trends in warming have continued at global, national, and regional scales. Global surface temperatures in the last decade (2010s) were estimated to be 1.09 °C higher than the 1850-1900 baseline period, with larger increases over land ~1.6 °C compared to oceans ~0.88 (IPCC 2021). The vast majority of this warming has been attributed to anthropogenic releases of greenhouse gases (IPCC 2021). Globally, 2014-2018 were the five warmest years on record, both on land and in the ocean (2018 was the 4th warmest) (NOAA NCEI 2022). 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 (IPCC 2022). These two factors are often examined in isolation but likely have interacting effects on ecosystem function.

Updated projections of climate change are similar to or greater than previous projections (IPCC 2021). NMFS is increasingly confident in our projections of changes to freshwater and marine systems because every year brings stronger validation of previous predictions in both physical and biological realms. Retaining and restoring habitat complexity, access to climate refuges (both flow and temperature), and improving growth opportunity in both freshwater and marine environments are strongly advocated in the recent literature (Siegel and Crozier 2020).

Salmon and Steelhead Habitat Changes

Climate change is systemic, influencing freshwater, estuarine, and marine conditions. Other systems are also being influenced by changing climatic conditions. Literature reviews on the impacts of climate change on Pacific salmon (Crozier 2015, 2016, 2017; Crozier and Siegel 2018; Siegel and Crozier 2019, 2020) have collected hundreds of papers documenting the major themes relevant for salmon. Here we describe habitat changes relevant to Pacific salmon and steelhead.

1. Forests and Wildfires

Climate change will impact forests of the western U.S., which dominate the landscape of many watersheds in the region. Forests already show evidence of increased drought severity, forest fire, and insect outbreak (Halofsky et al. 2020). Additionally, climate change will affect tree reproduction, growth, and phenology, which will lead to spatial shifts in vegetation. Halofsky et al. (2018) projected that the largest changes will occur in low- and high-elevation forests, with expansion of low-elevation dry forests and diminishing of high-elevation cold forests and subalpine habitats.

A major emergent habitat concern since the 2016 5-year review is the increased frequency and severity of large unprecedented wildfires throughout the CC Chinook salmon ESU. Forest fires affect salmon streams by altering sediment load, channel structure, and stream temperature through the removal of the tree canopy. High-intensity wildfire has the greatest potential to damage aquatic habitat through increased surface erosion and increased risk of landslides that deliver large quantities of sediment to streams. Intense fire can produce extensive areas of water-repellant soils, which combine with widespread vegetation loss to reduce water infiltration and create an elevated runoff response to precipitation events (USFS 2018). This sudden increase in overland and instream flow renders channels vulnerable to fine sediment delivery through erosion and large hillslope failures. Existing culverts have been burned or, where they still exist, overwhelmed by debris jams with flow eventually eroding through the road prism. Further, freshly excavated roads, and fire breaks cut by bulldozers to access and stop a fire's movement, remove vegetation and expose soil. If these excavations are not rehabilitated before the rainy season, they may confine runoff and promote rill erosion. Damage to riparian habitat significantly reduces stream shading, instream large wood, and long-term recruitment of large woody material input. It also decreases upslope filtering of mobilized sediments by organic material. Ultimately, water quality and fisheries habitat are degraded by accelerated surface runoff and erosional processes (surface erosion and increased landslide risk) that produce elevated nutrients, suspended sediment, turbidity, and accumulation of fines in pool habitat and spawning beds.

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 toward more extensive and severe forest fires and the continued expansion of fires into higher elevation and wetter forests (Alizedeh 2021). Climate change may also increase insect outbreaks and other pathogens affecting coastal Douglas-fir forests in the Pacific Northwest. Research by Agne et al. (2018) suggests 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 climate impacts will differ by region and forest type due to complex interacting effects of disturbance and disease.

2. Freshwater Environments

The following is excerpted from Siegel and Crozier (2019), who present a review of recent scientific literature evaluating the effects of climate change, describing the projected impacts of climate change on instream flows:

- 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. Sridhar et al. (2018), 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. Projections using representative concentration pathway (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.

As cited in Siegel 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). Isaak et al. (2018) concluded that most stream habitats will likely remain suitable for salmonids in the near future, with some becoming too warm. However, in cases where dams and other barriers restrict habitat access, salmon and steelhead will be confined to downstream reaches that are typically most at risk of rising temperatures unless passage is restored (FitzGerald et al. 2020; Myers et al. 2018). Streams with intact riparian corridors and 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 Pacific salmon and many other species. 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: 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, generally scored lowest, and thus were prioritized for conservation and restoration. Still, forest fires can increase stream temperatures dramatically in short time-spans by removing riparian cover (Koontz et al. 2018), and streams that lose their snowpack with climate change may see the largest increases in stream temperature due to the removal of temperature buffering (Yan et al. 2021). These processes may threaten some habitats that are currently considered refugia.

3. Drought

At the time of the 2016 5-year review, California had experienced well below average precipitation from 2012-2015 and record-high surface air temperatures during 2014 and 2015. This drought has had some lasting impacts past 2015. In water years 2017 and 2018, rainfall was plentiful and, while summer streamflow conditions increased, they did not return to the levels recorded before the drought (Dolman et al. 2019). The decrease in streamflow shows that the drought had cumulative impacts on the alluvial aquifer and groundwater conditions (Dolman et al. 2019). As the quantity and severity of droughts continue, the cumulative impacts will become more limiting in the recovery of CC Chinook salmon.

In 2020-2022, California experienced a historically severe drought. All habitat in the CC Chinook salmon ESU is categorized as in an exceptional drought (the most severe rating possible) by the National Integrated Drought Information System and NOAA (Figure 3).[6] For 2021-2022, California is on target to be in another severe drought. The impacts on the affected CC Chinook salmon populations will not be fully apparent until monitoring occurs when they return as adults.

[6] https://www.drought.gov/states/california

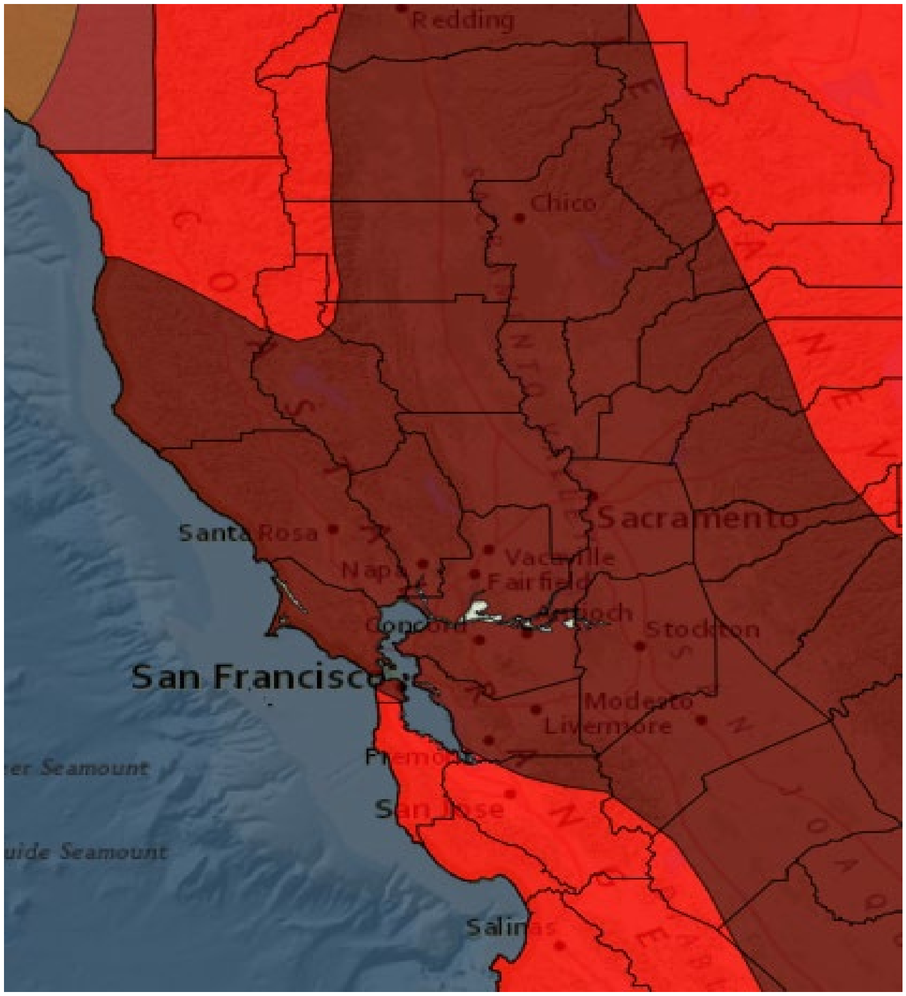


Figure 3. Drought Monitoring Conditions for California. The darker the color the more severe the drought conditions. The dark red areas are in an exceptional drought. The bright red areas are in an extreme drought. Credit: National Integrated Drought Information System and NOAA (2021).

4. Marine and Estuarine Environments

Along with warming stream temperatures and concerns about sufficient groundwater to recharge streams, a recent study projects a 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.

Rising ocean temperatures, stratification, ocean acidity, hypoxia, algal toxins, and other oceanographic processes will alter the composition and abundance of a vast array of oceanic species. In particular, there will be dramatic changes in both predators and prey of Pacific salmon, affecting both salmon life history traits and relative abundance. Siegel 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 similarly affect 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.

Perhaps the most dramatic change in physical ocean conditions will occur through ocean acidification and deoxygenation. It is unclear how sensitive salmon and steelhead might be to the direct effects of ocean acidification because of their tolerance to a wide pH range in freshwater (although see Ou et al. 2015 and Williams et al. 2019). However, the impacts of ocean acidification and hypoxia on sensitive species (e.g., plankton, crabs, rockfish, groundfish) will likely affect salmon indirectly through their interactions as predators and prey. Similarly, increasing frequency and duration of harmful algal blooms may affect salmon directly, depending on the toxin (e.g., saxitoxin vs. domoic acid), but will also affect their predators (seabirds and mammals). The full effects of these ecosystem dynamics are not known but will be complex.

5. Thiamine Deficiency

Ocean conditions remain a critical component to salmon survival and reproductive success since they spend the majority of their lives in the ocean. Thiamine deficiency can occur in adult Chinook salmon and influence their reproductive success and the health of their progeny (Harder et al. 2018). In fall and winter of 2019, Chinook salmon populations in the Central Valley of California (fall-, spring-, and late fall-run) were diagnosed with thiamine deficiency complex (TDC) (SWFSC 2022). This diagnosis was based on high rates of early life stage mortality observed in hatcheries and rapid recovery of juveniles exhibiting aberrant swimming behaviors following thiamine treatment by the USFWS California-Nevada Fish Health Center (Foott 2020). The primary hypothesis for TDC in Central Valley salmon is that a reorganization of food webs in the central California Current resulted in the dominance of northern anchovy in salmon diets (SWFSC, 2022). Northern anchovy possess thiaminase, an enzyme that breaks down vitamin B1, and diets high in northern anchovy can cause thiamine deficiency in their consumers, which can appear as high mortality or serious sublethal effects in subsequent progeny (SWFSC 2022). It is unclear the extent to which female Sacramento River winter-run Chinook salmon have low concentrations of thiamine in their eggs that would result in acute mortality and/or latent effects in their progeny in the wild (SWFSC 2022). Current research aims to gain a better understanding of this emerging stressor and potential treatment options to mitigate these nutritional deficiencies. Chinook salmon that returned to northern California hatcheries in the winter of 2021-2022 may have also experienced thiamine deficiency. Further research is needed to discover the impact of TDC in CC Chinook salmon.

6. Impacts on Salmon

Within the historical range of climate variability, less suitable conditions for salmonids (e.g., warmer temperatures, lower streamflows) have been associated with detectable declines in many of the ESA-listed Pacific salmon and steelhead species, highlighting how sensitive they are to climate drivers (Ford 2022; Lindley et al. 2009; Williams et al. 2016; Ward et al. 2015). In some cases, the combined and potentially additive effects of poorer climate conditions for fish and intense anthropogenic impacts caused the population declines that led to these population groups being listed under the ESA (Crozier et al. 2019).

In freshwater, year-round increases in stream temperature and changes in flow will affect physiological, behavioral, and demographic processes in salmon, and change the species with which they interact. For example, as stream temperatures increase, many native salmonids face increased competition with more warm-water tolerant invasive species. Changing freshwater temperatures are likely to affect incubation and emergence timing for eggs, and egg survival in locations where the greatest warming occurs, although several factors impact intergravel temperature and oxygen (e.g., groundwater influence) as well as sensitivity of eggs to thermal stress (Martin et al. 2017). Changes in temperature and flow regimes may alter the amount of habitat and food available for juvenile rearing. This, in turn, could lead to a restriction in the distribution of juveniles, further decreasing productivity through density dependence. Rising river temperatures increase the energetic cost of migration and the risk of *en route* or pre-spawning mortality of adults with long freshwater migrations, although populations of some ESA-listed salmon and steelhead may be able to make use of cool-water refuges and run-timing plasticity to reduce thermal exposure (Keefer et al. 2018; Barnett et al. 2020).

Marine survival of salmonids is affected by a complex array of factors including prey abundance, predator interactions, the physical condition of salmon within the marine environment, and carryover effects from the freshwater experience (Holsman et al. 2012; Burke et al. 2013). It is generally accepted that salmon marine survival is size-dependent, and thus larger and faster growing fish are more likely to survive (Gosselin et al. 2021). Furthermore, early arrival timing in the marine environment is generally considered advantageous for populations migrating through the Columbia River. However, the optimal day of arrival varies across years, depending on the seasonal development of productivity in the California Current, which affects prey available to salmon and the risk of predation (Chasco et al. 2021). Siegel and Crozier (2019) point out the 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.

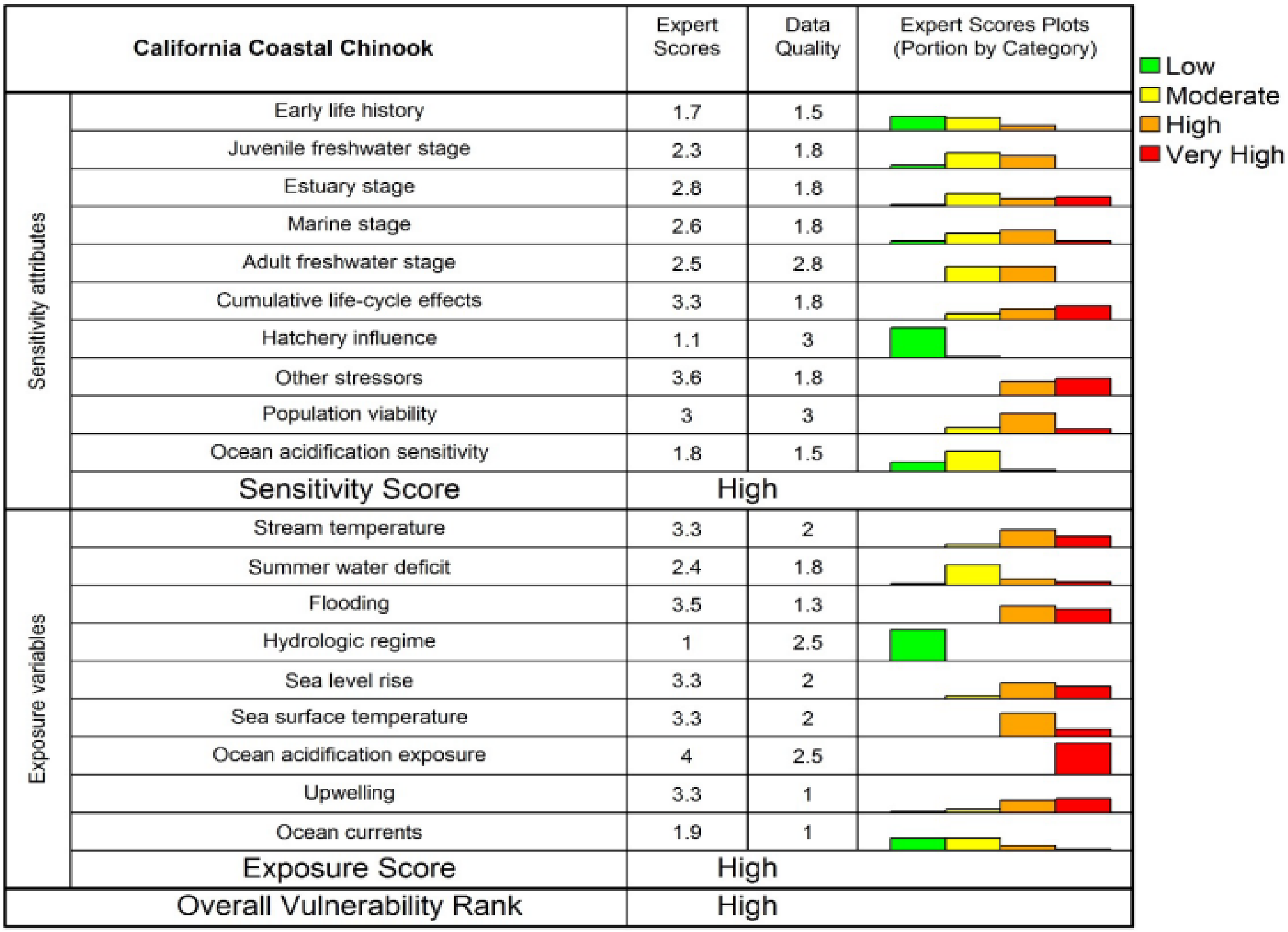
At the individual scale, climate impacts on salmon in one life stage generally affect body size or timing in the next life stage and negative impacts can accumulate across multiple life stages (Healey 2011; Wainwright and Weitkamp 2013; Gosselin et al. 2021). Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool season precipitation, snow accumulation, and runoff could influence migration cues for fall, winter and spring salmon and steelhead migrants. 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 (Crozier and Zabel 2006; Crozier et al. 2010; Crozier et al. 2019).

At the population level, the ability of organisms to genetically adapt to climate change depends on how much genetic variation currently exists within salmon populations, as well as how selection on multiple traits interact, and whether those traits are linked genetically. While genetic diversity may help populations respond to climate change, the remaining genetic diversity of many populations is highly reduced compared to historic levels. For example, 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 as well as reductions in haplotype and nucleotide diversity. Genetic losses in this comparison appeared larger for Chinook salmon from the mid-Columbia than those from the Snake River basin. In addition to other stressors, modified habitats and flow regimes may create unnatural selection pressures that reduce the diversity of functional behaviors (Sturrock et al. 2020). Managing to conserve and augment existing genetic diversity may be increasingly important with more extreme environmental change (Anderson et al. 2015), though the low levels of remaining diversity present challenges to this effort (Freshwater 2019). Salmon historically maintained relatively consistent returns across variation in annual weather through the portfolio effect (Schindler et al. 2015), in which different populations are sensitive to different climate drivers.

7. Species-Specific Climate Effects (from Crozer et al. 2019)

Climate effects on abundance and distribution: CC Chinook salmon comprise the southern coastal limit of distribution for Chinook salmon, and thus already face numerous limiting factors from climate change impacts. This vulnerability to climate effects stems from an array of sensitivity attributes and exposure variables, leading to cumulative impacts throughout the life cycle (Figure 6). For example, changes in precipitation patterns and temperature rise are expected to impact various freshwater life stages that propagate throughout the life cycle. Egg life stages are likely to be exposed to redd scour and sedimentation from increasing rainfall intensity, and changes to instream temperatures and flow conditions may result in earlier emergence and limit the fraction of juveniles migrating or holding in freshwater during summer months. These kinds of changes could create mismatches between migration timing and favorable conditions. Thus, this ESU ranks high in exposure to stream temperature impacts caused by climate change. In addition, climate change could also affect estuary habitat quality, making the estuarine life stage of CC Chinook salmon highly sensitive to climate change. Marine life stages are expected to have high exposure to changes in upwelling, ocean acidification, and increasing sea surface temperatures. Overall, the ESU ranks high for exposure to climate change effects, as well as biological sensitivity and overall vulnerability to these effects.

Climate change effects and adaptive capacity: this ESU is at the southern coastal range limit for Chinook salmon, and may be limited in its ability to modify its life history to adapt to climate change. Increasing temperatures are expected to make conditions in summer holding pools less favorable, which will likely reduce opportunities for the currently extirpated spring-run life-history to be re-expressed. The CC Chinook salmon ESU is, therefore, ranked low for adaptive capacity and is vulnerable to increased risk of extinction as existing threats are exacerbated by climate change effects. Ongoing, long-term efforts to improve habitat conditions and maintain genetic diversity will aid resilience over time.



California Coastal Chinook		Expert Scores	Data Quality	Expert Scores Plots (Portion by Category)
Sensitivity attributes	Early life history	1.7	1.5	
	Juvenile freshwater stage	2.3	1.8	
	Estuary stage	2.8	1.8	
	Marine stage	2.6	1.8	
	Adult freshwater stage	2.5	2.8	
	Cumulative life-cycle effects	3.3	1.8	
	Hatchery influence	1.1	3	
	Other stressors	3.6	1.8	
	Population viability	3	3	
	Ocean acidification sensitivity	1.8	1.5	
	Sensitivity Score	High		
Exposure variables	Stream temperature	3.3	2	
	Summer water deficit	2.4	1.8	
	Flooding	3.5	1.3	
	Hydrologic regime	1	2.5	
	Sea level rise	3.3	2	
	Sea surface temperature	3.3	2	
	Ocean acidification exposure	4	2.5	
	Upwelling	3.3	1	
	Ocean currents	1.9	1	
	Exposure Score	High		
Overall Vulnerability Rank		High		

Figure 3. CC Chinook salmon Vulnerability due to Climate Effects from Sensitivity Attributes and Exposure Variables (Crozier et al. 2019).

Small Population Size

Most populations within the CC Chinook salmon ESU have declined in abundance to levels that are well below low-risk abundance targets, and several are, if not already extirpated, likely below the high-risk depensation thresholds specified by Spence et al. (2008). These small populations are at risk from natural stochastic processes, in addition to deterministic threats, that may make recovery of this ESU difficult to achieve. As natural populations get smaller, stochastic processes may cause alterations in genetics, breeding structure, and population dynamics that may undermine the potential success of habitat enhancement recovery efforts and need to be considered when evaluating how populations may respond to potential and/or implemented recovery actions.

Three of four Diversity Strata within the CC Chinook salmon ESU have essential and supporting recovery populations that are likely experiencing detrimental population dynamics due to absent or low abundance levels; far below what is needed to support the population viability criteria (NMFS MSP Recovery Plan 2016a). These Diversity Strata and populations include: (1) North Coastal Diversity Stratum: Bear River, Humboldt Bay Tributaries, Little River, and Redwood Creek; (2) North-Central Coastal Diversity Stratum: Big River, Noyo River, Ten Mile River, and Albion River; and (3) Central Coastal Diversity Stratum: Garcia River, Navarro River, and Gualala River. The North Mountain Interior Diversity Stratum and other ESU populations not listed above likely have enough individual recruitment to establish a recovery trajectory without the assistance of a population augmentation program.

Implementation of a population augmentation program(s) to improve population viability (density, abundance, and spatial structure) would require detailed and strategic planning to justify the action. Population augmentation investigations prior to establishing a program should include, but not be limited to the following: identify if the population(s) is at short-term or immediate risk of extinction; identify the biological or ESU significance of the subject population(s); determine the current population dynamics, genetics, and viability status; identify the population viability goals and the expectations of a population augmentation program(s); determine the habitat capacity and associated limiting factors for targeted populations; and identify where a population augmentation program(s) will contribute or complement other recovery efforts.

Hatchery Effects

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 to salmon and steelhead, 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 risk depends on the status of affected populations and on specific practices in the hatchery program. Hatchery programs can affect naturally produced populations of salmon and steelhead in a variety of ways, including competition (for spawning sites and food) and predation effects, disease effects, genetic effects from straying hatchery stocks (e.g., outbreeding depression, domestication selection, etc.), broodstock collection effects (e.g., to population diversity), and facility effects (e.g., water withdrawals, effluent discharge) (NMFS 2018).

Currently, there are no CC Chinook salmon or other Chinook salmon stock hatchery propagation programs within the ESU; and, therefore, hatcheries are not a direct threat to the species.

Research, Monitoring and Evaluation

1. Coastal Monitoring Program

The CDFW/NMFS Coastal Monitoring Program (CMP), described in Adams et al. 2011 (e.g., CDFW Fish Bulletin 180), draws on the viable salmonid population framework of McElhaney et al. 2000 to assess salmonid viability in terms of the four-population metrics: abundance, productivity, spatial structure, and diversity. CMP divides the coastal zone of California into northern and southern areas based on differences in species composition, levels of abundance, distribution patterns, and habitat differences that require distinct monitoring approaches. Useful CMP data that can contribute to adult spawner abundance estimates include, but not limited to, redd surveys of stream reaches derived from statistically-valid sampling design based on spawner to redd ratios, redd surveys and estimates that are not expanded to adult estimates (e.g., no spawner to redd ratio estimates available), sonar counts, and adult weir counts (Shasta and Scott rivers). More recently, SWFSC and CDFW have been working on more specific application of monitoring approaches to better address population monitoring specifics that present unique environmental conditions for select species. The viability assessment conducted by SWFSC informs this 2024 5-year review and assesses progress to meeting viability targets at the population and ESU/DPS level in terms of extinction risk.

The longer time series available in the northern monitoring area, since CMP has been implemented, have improved our ability to assess status and trends for a number of salmon and steelhead populations. These data are either approaching or exceeding the four generation criteria for evaluating recovery plan downlisting and delisting criteria (e.g., Mendocino coast, Scott Creek LCM station in Santa Cruz County, Russian River in Sonoma/Mendocino counties, Lagunitas/Olema Creek in Marin County). These data have also improved our ability to assess the status of smaller populations, which were poorly understood prior to implementation of CMP (e.g., Caspar Creek, Little River, Redwood Creek [Marin County]). Information on selected populations (Redwood Creek [Humboldt County], Mad River, Eel River) has improved with installation of sonar cameras.

Unfortunately, lapses in funding have resulted in some programs being interrupted (e.g., Navarro and Garcia rivers) or discontinued with no resumption in sight (e.g., Santa Cruz Mountain Diversity Stratum; some populations on the Mendocino Coast with long time series [Caspar Creek, Little River], and the Smith River for SONCC coho salmon). Furthermore, spatial coverage has been lacking in the southern monitoring area and remains highly patchy in other geographies (e.g., Trinity River). Some sampling efforts primarily target coho salmon and so do not encompass the entire spatial or temporal extent of spawning for other listed species such as CC Chinook salmon, and several populations identified as essential to recovery are not currently monitored (i.e., steelhead in Eel River subbasins and the San Francisco Bay Area).

Intermittent implementation and methodological issues continue to hinder assessment of a number of populations. CMP nonetheless provides a substantially better basis for informing NMFS' recovery and viability criteria compared with previous assessments and 5-year reviews and will increase greatly in value as these time series become longer. Long-term dedicated resources to support California's monitoring program to answer critical scientific questions are needed.

2. Eel River Adult CC Chinook Escapement Monitoring – Sonar Network

A pilot study investigating the use of sonar technology to estimate adult salmonid returns in the Eel River occurred in fall/winter 2018/19, 2019/20, and 2020/21. Results from all annual efforts showed meaningful estimates for the Upper Eel River Chinook population and a portion of the Lower Eel River Chinook population (SF Eel River). The Eel River contains two essential populations of CC Chinook salmon, Upper and Lower Eel River; however, without strategic placement of a sonar network or sufficient escapement monitoring within the Van Duzen River, Lower Eel River Chinook salmon population estimates are only speculative. Current NMFS sonar network partners include CDFW Region 1, CalTrout, Trout Unlimited, Round Valley Indian Tribes, and PG&E. Each of these entities are committed to this effort and continue to search for long-term funding as the partners agree that operating sonars concurrently within the Upper Eel River, South Fork Eel River, Middle Fork, and the Van Duzen River is the most viable strategy for achieving a complete escapement estimate for the Eel River watershed.

The benefits of establishing a long-term escapement monitoring program in the Eel River include:

- best population coverage for all north coast salmonid populations;
- avoids splitting the Lower Eel River Chinook population by sonar placement only in the South Fork;

- significantly informs annual gravel mining efforts to improve passage/avoid stranding at the Van Duzen confluence;
- provides robust information for exposure and abundance for program/enforcement work; informs Potter Valley Project effects on Chinook salmon populations within the Eel River;
- informs in-river fishing and ocean harvest activities;
- supports MSP Recovery Plan Actions specific to adult abundance monitoring;
- supports 5-year Review recommendations;
- supports Eel River tribal interests; and
- supports the recommendations of the joint NMFS and CDFW California Coastal Chinook Salmon Fishery Management: Future Prospects Technical Memorandum (O'Farrell et al. 2015).

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 5 years. While conducting these reviews, we apply the provisions of ESA section 4(a)(1) and NMFS's implementing regulations at 50 CFR part 424.

We review the status of the species and evaluate whether any of the five factors, as identified in ESA section 4(a)(1), suggests that a reclassification is warranted: (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; or (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, and accounting for efforts by states and foreign governments to protect the species.

Updated Biological Risk Summary

As summarized in SWFSC (2022), data availability and reliability for the CC Chinook salmon ESU has improved since the last viability assessment, particularly in the northern part of the ESU. Relatively new sonar-based monitoring programs in several watersheds have replaced index-reach surveys at strategic locations and are indicating that some populations within the ESU might be doing better than believed in prior assessments (Mad River and Redwood Creek).

However, trends in the longer time series for other populations are mixed, with some showing notable decline in abundance (Russian River, Eel River, Mendocino Coastal rivers, and Freshwater Creek). In summary, the most recent information available indicates that recent trends across the ESU have been mixed and that overall extinction risk for the ESU is moderate and has not changed appreciably since the 2016 viability assessment.

ESA Listing Factor Analysis

Listing Factor A (habitat): We conclude that since the previous 5-year review, the risk to CC Chinook salmon persistence because of habitat conditions has not improved and is increasing. Habitat improvement remains a priority objective throughout this ESU, particularly with regard to habitat quality, stream flow, and water temperature in areas that exceed water quality standards due to anthropogenic causes.

Listing Factor B (overutilization): We conclude that since the previous 5-year review, the risk to CC Chinook salmon persistence because of overutilization and scientific study remains low, because no direct take occurred in any commercial or recreational fishery, and the amount of take for scientific study is limited.

Listing Factor C (disease and predation): We conclude that since the previous 5-year review, the risk to CC Chinook salmon persistence because of disease or predation remains low. But given the lack of information currently available in California, further study of pinniped predation interactions is warranted to determine whether these impacts are limiting the recovery of ESA-listed salmon and steelhead in the state.

Listing Factor D (inadequacy of existing regulatory mechanisms): New information available since the previous 5-year review indicates that the adequacy of a number of regulatory mechanisms has improved slightly, with more mechanisms showing the potential for some improvement, and fewer mechanisms that are making the protection and recovery of CC Chinook salmon challenging.

Listing Factor E (other manmade or natural factors): We conclude that since the previous 5-year review, the overall risk to CC Chinook salmon persistence because of other manmade and natural factors remains high because of the major threat of climate change, droughts, wildfires and ocean conditions. CC Chinook salmon are especially vulnerable to the projected changing climate; especially in watersheds where reservoir management and water reliability are critical to support their life-history patterns. Although there are no CC Chinook salmon hatchery propagation programs within the CC Chinook salmon ESU, predation by Russian River hatchery released steelhead smolts continues to threaten smaller naturally produced listed CC Chinook salmon, CCC steelhead and CCC coho salmon.

Conclusion

Although conservation efforts for CC Chinook salmon have reduced some threats for this ESU, the threats described in the five listing factor discussions above have, with few exceptions, remained unchanged since the previous 5-year review (NMFS 2016b). Habitat conditions and access have improved due to numerous habitat restoration projects, and relatively small-scale fish passage projects. Reservoir operations have also improved instream flows for CC Chinook salmon in the Eel and Russian rivers since the last 5-year review, helping maintain those populations. Conversely, habitat problems are still common throughout the region, legacy effects persist in many areas, new urban growth threatens existing habitat, and many more habitat improvements and protections are likely important to achieve viability. Harvest rates remain relatively low for CC Chinook salmon, and the protection afforded by some regulatory mechanisms, such as implementation of TMDLs and CDFW Sport Fishing Regulations, has increased. However, we remain concerned about the adequacy of several existing regulatory mechanisms to allow for survival and recovery of the species. In particular, ongoing impacts from urbanization, impassable dams, and diversion facilities (including small diversions as well as large dams) continue to impair habitat and threaten the continued persistence of CC Chinook salmon.

While historical threats, such as timber harvest and commercial exploitation, have lessened during the past few decades, other previously unidentified threats, often linked to climate change, have worsened, and will likely worsen further in the coming decades. The risk and impact of wildfires on CC Chinook salmon habitat have been widespread and will continue. Shifts in oceanographic dynamics, such as sea-surface temperatures, wind patterns, and coastal upwelling can alter salmon migration patterns and decrease food availability, greatly impacting CC Chinook salmon survival in the marine environment. Likewise, shifting temperature and precipitation patterns throughout the western U.S. are expected to significantly alter riverine hydrologic patterns, with warmer winter temperatures leading to less snowpack storage, more intense runoff events, and lower streamflows during dry periods. Overall, California has been a leader in addressing climate change through innovative technology and regulation, but international solutions are likely key to reduce threats to CC Chinook salmon linked to climate change, given the global nature and extent of the issue.

After considering the biological viability of CC Chinook salmon and the current status of its

ESA section 4(a)(1) factors, we conclude that the risk to the persistence of the CC Chinook salmon ESU has not changed significantly since the 2016 5-Year Review (NMFS 2016b).

2.4.1 ESU/DPS Delineation and Hatchery Membership

- The SWFSC's assessment (SWFSC 2022) found that no new information had become available that would justify a change in the delineation of the CC Chinook salmon ESU.

- There are currently no hatchery programs in the CC Chinook salmon ESU (70 FR 37160, June 28, 2005), and the West Coast Regional Office's 2024 review of new information since the previous 5-year review regarding the various hatchery programs indicates no programs warrant inclusion in this ESU.

2.4.2 ESU/DPS Viability and Statutory Listing Factors

- The SWFSC's assessment of updated information (SWFSC 2022) suggests no change in the biological risk category of CC Chinook salmon since the time of the last viability assessment (Spence 2016; Williams et al. 2016).

- Our analysis of ESA section 4(a)(1) factors indicates that the collective risk to CC Chinook salmon persistence has not changed significantly since our previous 5-year review (NMFS 2016b).

3. Results

3.1 Classification

Listing Status:

Based on the information identified above, we recommend that the CC Chinook salmon ESU remain listed as threatened.

ESU Delineation:

The SWFSC's viability assessment (SWFSC 2022) found that no new information has become available that would justify a change in the delineation of the CC Chinook salmon ESU.

Hatchery Membership:

There are no hatchery programs within the CC Chinook salmon ESU, and no programs that currently warrant inclusion in the ESU.

3.2 New Recovery Priority Number

Since the 2016 5-year review, NMFS revised the recovery priority number guidelines in 2019 and reevaluated the numbers most recently in the 2021-2022 Recovering Threatened and Endangered Species Report to Congress (NMFS 2023). Table 4 indicates the number in place for the CC Chinook ESU at the beginning of the current review (3C).

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

4. Recommendations for Future Actions

In our review of the five listing factors, we identified several actions critical to improving the status of the CC Chinook salmon ESU. NMFS provided a number of recommended actions in the 2016 5-year review that are still relevant at this time. In this review, we focus on the most important actions to pursue over the next 5 years to improve passage, habitat, flows, and population viability for CC Chinook salmon. Passage improvements are important to remedy both partial and complete barriers to migration and reach-scale movement of adults and juveniles. Habitat improvements should include attention to in-stream and estuarine habitat complexity, and the geomorphic and watershed processes that support habitat function. Flow protections and improvements are important to protect all life stages and habitat, and should support base (low) flows, natural-type hydrographs, and groundwater resources. Improved population monitoring is important to better understand the status of populations and the ESU.

We are directing our efforts at populations that need viability improvement according to ESU-, diversity stratum-, and population-level recovery criteria; the best available scientific information concerning ESU status; the role of the independent populations in meeting ESU and diversity stratum viability; limiting factors and threats, and the likelihood of action effectiveness to guide our recommendations for future actions. NMFS is coordinating with the Federal, state, tribal, and local implementing entities to ensure that risk factors and actions identified in the recovery plan and the actions identified in key consultations in this geography are addressed.

The following identifies the most important actions to pursue over the next 5 years. Please review the section for each individual listing factor for more information on the high priority actions.

Key Actions:

- Decommission the Potter Valley Project, specifically the removal of Scott and Cape Horn dams, Eel River, California.

- Develop and implement actions toward addressing the chronic turbidity problem associated with Lake Mendocino, Russian River, California.

- Implement reservoir measures including improved water operations that protect water quality conditions and provide strategic water releases adequate for CC Chinook salmon.

- Incorporate CC Chinook salmon into the California Coastal Monitoring Program.

- Fund and implement a coordinated program to enable tracking of CC Chinook salmon and the component populations, evaluate the effectiveness of restoration and mitigation efforts targeting this ESU, and to ensure the monitoring program will meet data needs to conduct 5-year reviews for CC Chinook salmon. Specifically, continue to develop and implement a strategic CC Chinook salmon adult escapement monitoring plan for the Eel River utilizing sonar technology (e.g., DIDSON, ARIS, etc.) within the Van Duzen, South Fork Eel River, mainstem Eel River, and Middle Fork Eel River. These should be a top monitoring priority for the CC Chinook salmon ESU.

- Enhance conservation actions. Reduce poaching, modify sport fishing regulations where appropriate, provide greater support for law enforcement, and increase outreach to the public.

Listing Factor A:

See Section 2.3.2 discussion on Listing Factor A for more information on important recovery actions by diversity stratum.

- Develop drought contingency plans for reservoirs within the Russian, Eel, and Mad rivers to ensure adequate water quantity and quality for adult and juvenile CC Chinook salmon during critically dry water years.

- Retain, recruit and actively input large wood into streams; specifically targeting holding and staging habit for adult CC Chinook salmon.

- Design and implement restoration projects to create or restore alcove, floodplain, backwater channel, ephemeral tributary, or seasonal habitats.

- Restore and protect dry season flows, by encouraging water conservation and winter diversions (off-stream storage).

- Minimize new road construction within floodplains, riparian areas, or upon unstable soils or other sensitive areas. Design new roads that are hydrologically disconnected from the stream network.

- Promote and fund habitat enhancement projects improving the quality and extent of estuary habitat within CC Chinook salmon ESU essential recovery populations.

Listing Factor B:

- With appropriate involvement of CDFW and local partners, address illegal fisheries activities throughout the range of the CC Chinook salmon ESU.

- With appropriate involvement of CDFW and local partners, continue to develop protective regulations to minimize impacts from fishing during migratory periods (e.g., until sandbars open naturally) within one mile of the river mouths of the focus watersheds, and to improve freshwater sport fishing regulations to minimize take and incidental mortality of listed salmonids. Considerations may include improved low-flow closure thresholds, seasonal fishing closures, and angler outreach programs. An evaluation of current low-flow closure thresholds is desired for the mainstem Eel River to ensure proper protection and potentially reduce mortality of Chinook salmon during the catch-and-release steelhead season.

- With federal, state, county, and other local partners, develop and implement a CC Chinook salmon management plan that incorporates ocean harvest and freshwater escapement with focus on the Eel and Russian rivers as the anchor recovery populations for the ESU.

Listing Factor C:

- Expand, develop, fund and implement monitoring efforts to identify pinniped predation interactions in select areas, e.g., river mouths/migratory pinch points, and quantitatively assess predation impacts by pinnipeds on CC Chinook salmon.

- Reduce predation by Sacramento pikeminnow and other predatory invasive species, including:
    - Continue to work collaboratively with Eel River partnerships to reduce the abundance of Sacramento pikeminnow throughout the Eel River.
    - Continue to support and complete the study on Sacramento pikeminnow in the South Fork Eel River being conducted by Stillwater Sciences and the Wiyot Tribe.

- Continue to refine PG&E's monitoring and suppression program for Sacramento pikeminnow in Lake Pillsbury and in between Scott and Cape Horn Dams. Ensure that the new FERC license for the Potter Valley Project has an adequate Sacramento pikeminnow removal component planned for Lake Pillsbury prior to, during, and after the removal of Scott Dam.

Listing Factor D:

- In collaboration with CDFW, develop Fisheries Management and Evaluation Plans (FMEP) that: (1) incorporate delisting criteria; (2) determine impacts of fisheries management in terms of Viable salmonid population (VSP) parameters; (3) do not limit attainment of population-specific criteria; (4) annually estimate the commercial and recreational fisheries bycatch and mortality rate; (5) are specifically designed to monitor and track catch and mortality of wild and hatchery salmon and steelhead stemming from recreational fishing in freshwater and the marine habitats; and (6) provide for adaptive management options as needed to ensure actual fisheries impacts do not exceed those consistent with recovery goals.

- The State should prioritize completion of Total Maximum Daily Loads (TMDLs) for all CC Chinook salmon occupied water bodies that do not meet State water quality standards.

- In collaboration with local and State officials, develop drought management plans for unimpaired watersheds (free flowing, no reservoir) that include minimum flow thresholds that support all Chinook salmon life stages.

- Continue to work collaboratively with the Two-Basin Solution Partnership and Eel River interested parties toward the removal of Scott Dam and fish passage improvements at Cape Horn Dam.

- Continue to work collaboratively with the FIRO Steering Committee toward optimizing water storage reliability and flexibility within the Russian River (Lake Mendocino and Lake Sonoma), while providing improved water quantity and quality conditions for listed salmonids in the upper Russian River.

<u>Listing Factor E</u>:

- Climate Change Effects:
    - Prioritize mainstem and tributary habitat projects that improve habitat resiliency to climate change. Actions to restore riparian vegetation, streamflow, and floodplain connectivity and re-aggrade incised stream channels can ameliorate temperature increases, base flow decreases, and peak flow increases, thereby improving population resilience to some effects of climate change.

- Demographic Effects:
    - Evaluate and determine the need for a CC Chinook salmon population(s) augmentation program for essential recovery populations within the North Central (Mendocino County) and Central Coastal (Russian River) Diversity Strata.

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NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW

California Coastal Chinook Salmon ESU

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 California Coastal Chinook Salmon ESU Evaluation Team

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, NOAA Fisheries

Approve RUVELAS.PENNY.1365830491 Digitally signed by RUVELAS.PENNY.1365830491 Date: 2024.11.25 14:10:33 -08'00' Date: ________

Cooperating Regional Administrator, NOAA Fisheries

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

Signature____ Date: _______

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

[x] Concur [ ] Do Not Concur

Signature RAUCH.SAMUEL.DEAN.1365850948 Digitally signed by RAUCH.SAMUEL.DEAN.1365850948 Date: 2024.12.03 12:38:43 -05'00' Date: _______