Science, Service, Stewardship

2023 5-Year Review: Summary & Evaluation of **South-Central California Coast Steelhead**

National Marine Fisheries Service
West Coast Region

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5-Year Review: South-Central California Coast Steelhead DPS

Species Reviewed	Distinct Population Segment
Steelhead *Oncorhynchus mykiss*	*South-Central California Coast Steelhead*

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Table of Contents

List of Tables

List of Figures

Contributors
West Coast Region

Mark H. Capelli*
113 Harbor Way, Suite 150
Santa Barbara, CA 93109
(805) 963-6478
Mark.Capelli@noaa.gov

Fire Maps:
Richard Morse
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802
(562) 434-5091
richard.morse@noaa.gov

DPS Maps:
TJG Daniel E. Jessurun
777 Sonoma Avenue Room 325
Santa Rosa, CA 95404
(707) 578-8516
daniel.e.jessurun@noaa.gov

Reviewers

Nora Berwick (retired)
1201 NE Lloyd Blvd, Suite 1100
Portland, OR 97232

Joel Casagrande
777 Sonoma Ave., Room 325
Santa Rosa, CA 95405
(707) 575-6016
Joel.Casagrande@noaa.gov

Amanda Ingham
777 Sonoma Ave., Room 325
Santa Rosa, CA 95405
(707) 575-6083
Mandy.Ingham@noaa.gov

Robert Markle
1201 NE Lloyd Blvd, Suite 1100
Portland, OR 97232
(503) 230-5419
Robert.Markle@noaa.gov

Anthony P. Spina
501 West Ocean Boulevard, Suite 4200
Long Beach, CA 90802-4213
(562) 980-4029
Anthony.Spina@noaa.gov

William Stevens
777 Sonoma Ave., Room 325
Santa Rosa, CA 95405
(707) 575-6066
William.Stevens@noaa.gov

Southwest Fisheries Science Center

David A. Boughton
110 Shaffer Road
Santa Cruz, CA 94920
(831) 420-3920
David.Boughton@noaa.gov

Nathan J. Mantua
110 Shaffer Road
Santa Cruz, CA 94920
(831) 420-3923
Nathan.Mantua@noaa.gov

Tommy H. Williams
110 Shaffer Road
Santa Cruz, CA 94920
(831) 420-3912
Tommy.Williams@noaa.gov

Northwest Fisheries Science Center

Lisa Crozier
2725 Montlake Blvd. E.
Seattle WA 98112
(206) 860-3395
Lisa.Crozier@noaa.gov

Laurie Weitkamp
2032 SE Marine Science Drive
Newport, OR 97365
(541) 867-0504
Laurie.Weitkamp@noaa.gov

**** Lead author, South-Central/Southern California Steelhead Recovery Coordinator, West Coast Region, California Coastal Office***

1. General Information

1.1 Introduction

Pacific salmon and steelhead are comprised of six anadromous fish species in the genus *Oncorhynchus* that are native to the North American and Asian coasts of the North Pacific Ocean (Jordan and Gilbert 1882, Goode 1884, Jordan 1888, Jordan and Gilbert 1892, Moyle 2002, Augerot and Foley 2005, Berra 2007, Quinn 2018, and Spence 2019).[1] These fish species support valuable commercial and sport fisheries, and play an important role in the cultures of peoples native to the coasts and watersheds of the North Pacific Ocean, from Russia and Japan through Alaska and California (Magnuson *et al*. 1996). Pacific salmon and steelhead also play important and complex roles in their interactions with other species native to the marine and freshwater environments of the North Pacific region (Lackey *et al*. 2006).

Many Pacific salmon and steelhead (*Oncorhynchus* spp.) populations along the West Coast of North America (West Coast) have declined substantially and now are at a fraction of their pre-European historical abundance. There are several factors that have contributed to these declines, including: loss of freshwater and estuarine habitat, poor ocean conditions as result of anthropogenic activities such as water-supply and hydropower development, urban and agricultural land use practices; overfishing and hatchery practices, and more recently, climate changes (Busby *et al*. 1996, Stouder, *et al*. 1997, Good *et al*. 2005, Araki *et al*. 2007, 2008, 2009, Intergovernmental Panel on Climate Change 2021, Kocik *et al.* 2022). These factors led the National Marine Fisheries Service (NMFS) to list 28 West Coast Pacific salmon and steelhead populations 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

[1] The taxonomic status of steelhead has varied over time. In 1758, Linnaeus proposed the genus *Salmo* (Linnaeus 1758) for a variety of fish species, which originally included Atlantic salmon (*Salmo salar*), but which came to include many newly discovered salmon and trouts from lands bordering the North Pacific Ocean. Steelhead were originally placed in the genus *Salmo* with various specific names, including *mykiss* and *gairdneri*; *see* Steller (1740a, 1740b), Walbaum (1792), Suckley (1862, 1874), Gunther (1880), Jordan and Gilbert (1883), Goode (1884). In 1836, steelhead were classified as *Salmo gardinerii* (Richardson 1836), and in 1988 were placed in the genus *Oncorhynchus* (*O. mykiss* Walbaum 1792) along with the other Pacific salmon; *see* Richardson (1836), Smith and Stearley (1989), Stearley and Smith (1993), Melville (1995), Behnke (2002), Alagona (2016), Spence (2019).

2006, NMFS 2020; *see* also, NMFS 2022a. After completing a 5-year review, the Secretary must determine if any species should be: (1) removed from the list; (2) have its status changed from endangered to threatened; or (3) have its status changed from threatened to endangered. If, in the 5-year review, a change in classification is recommended, the recommended change will be further considered in a separate rule-making process.

The most recent 5-year review for West Coast Pacific salmon and steelhead occurred in 2016. This document describes the results of the 2023 review of the ESA-listed South-Central California Coast steelhead Distinct Population Segment (DPS).

A 5-year review is a:

- Summary and analysis of available information on a given species;
- Report on a species' progress toward recovery;
- Record of the deliberative process used to make a recommendation on whether or not to reclassify a species; and
- Recommendation on whether reclassification of the species is warranted.

A 5-year review is not a:

- Re-listing or justification of the original (or any subsequent) listing action;
- Process that requires acceleration of ongoing or planned surveys, research, or modeling;
- Petition process; or
- 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 (ESU) 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. NMFS considers an ESU as constituting a DPS and therefore a species under the ESA (56 FR 5812). NMFS originally listed south-central California steelhead as threatened under the ESU policy in 1997 (62 FR 43937), but in 2006 decided that steelhead should be considered under the joint United States Fish and Wildlife Service (USFWS) and NMFS DPS Policy (61 FR 4722), and listed the South-Central California Coast Steelhead DPS in 2006 (71 FR 834). Under the DPS policy, a DPS of steelhead must be discrete from other populations, and it must be significant to its taxon.

Artificial propagation programs (hatcheries) are common throughout the range of ESA-listed Pacific populations of salmon and steelhead. Prior to 2005, NMFS' policy was to include in the listed ESU or DPS only those hatchery fish[2] deemed essential for conservation of a species. NMFS revised that approach in response to a court decision (U.S. District Court 2001) and on June 28, 2005, 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). This policy establishes criteria for including hatchery salmon and steelhead in ESUs and DPSs. In addition, the policy: (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 NMFS' commitment to conserving natural salmon and steelhead populations and the ecosystems upon which they depend; and (4) affirms NMFS' 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, NMFS consider the origins of the hatchery stock, where the hatchery fish are released, and the extent to which the hatchery stock has diverged genetically from the donor stock. NMFS includes within the ESU or DPS (and therefore within the listing) hatchery fish that are no more than moderately diverged from the local native population.

Because the new Hatchery Listing Policy changed the way NMFS considered hatchery fish in ESA listing determinations, NMFS completed new reviews and ESA listing determinations for Pacific salmon ESUs on June 28, 2005 (70 FR 37159), and for steelhead DPSs on January 5, 2006 (71 FR 834). On August 15, 2011, NMFS noticed the availability of the 5-year reviews and listing recommendations for 11 ESUs of Pacific salmon and 6 DPSs of steelhead (76 FR 50448); *see* also, 76 FR 50447). On May 26, 2016, NMFS published the reviews and listing determinations for 17 ESUs of West Coast salmon and 10 DPSs of steelhead, and the southern DPS of eulachon (*Thaleichthys pacificus)* (81 FR 33468), including reaffirming the threatened status for the South-Central California Coast Steelhead DPS.

1.1.2 South-Central/Southern California Recovery Domain

The South-Central/Southern California Recovery Domain includes two listed geographically disjunct steelhead DPSs: southern California and south-Central California. Within this Domain there are two recovery planning areas which include all portions of the watersheds that drain to the Pacific Ocean: the South-Central Steelhead Recovery Planning Area and the Southern California Recovery Planning Area. The South-Central California Coast Steelhead DPS is a sub-

[2] As used here, the term "fish" is synonymous with "salmon" and "steelhead."

area that includes only the anadromous waters of the South-Central California Coast Steelhead Recovery Planning Area.

The South-Central/Southern California Recovery Domain covers coastal drainages from the Pajaro River at Monterey Bay south to the Tijuana River at the U.S. border with Mexico, a relatively arid region consisting mostly of shrublands (chaparral), grasslands, and oak savannah, but with coniferous forests at high elevations and along some stream corridors, especially within the Big Sur Coast and Carmel River regions. Stream systems tend to divide into numerous small coastal creeks within the climate zone of marine influence, and fewer larger inland river systems that drain the arid interior valleys. Many of these watersheds exhibit highly variable and erratic streamflows (Boughton *et al*. 2006); *see* also, Lang and Love (2014), NMFS (2013a).

The only native salmonid within the South-Central/Southern California Recovery Domain is *Oncorhynchus mykiss*. Busby *et al.* (1996) divided this taxonomically recognized species into two ESUs (now DPSs): the threatened South-Central California Coast Steelhead DPS—from the Pajaro River south to but not including the Santa Maria River—and, the endangered Southern California Steelhead DPS—from the Santa Maria River south to the U.S.-Mexico border. An important feature of these two DPSs is that they are typically composed of mixed populations of anadromous fish (steelhead) and freshwater resident fish (rainbow trout). The ratio of anadromous and non-anadromous *O. mykiss* in an individual population (or watershed) can vary considerably both geographically and temporally, depending on local conditions. See also the discussion and recommendation on monitoring the frequency of Omy5 “A” haplotype under “New Research Relevant to Population-Level Viability Criteria” and “Summary and Conclusions.” The steelhead component has been given ESA protection as a DPS. Based on the viable salmon population concept of McElhany *et al*. (2000), Boughton *et al.* (2007) developed viability criteria for steelhead at the population and DPS levels. A monitoring plan for the risk metrics was given broad conceptual outline by Adams *et al.* (2011) and updated for southern steelhead populations by Boughton *et al.* (2022); *see* also, HDR Engineering (2013), White *et al*. (2017), Hopkins *et al*. (2018), Capelli (2020a).

Importantly, the viability criteria recognized that the two listed DPSs of steelhead were typically components of mixed populations of rainbow trout and steelhead, but the genetic, physiologic and ecological controls on the expression of these two life-histories were poorly understood at the time of their original listing in 1997; *see* 62 FR 43937, Clemento *et al*. (2009), Pearse *et al*. (2011). Because of this uncertainty, the viability criterion for abundance was augmented by an additional criterion specifically for the anadromous fraction, defined as the proportion of reproducing adults that exhibit the anadromous life-history (Boughton *et al*. 2007); *see* also, Capelli (2018b). Because the controls on expression of anadromy were poorly understood, the criterion for anadromous fraction was set at 100 percent as a precautionary measure. The underlying rationale was that viable runs of steelhead (the anadromous component) cannot be assumed to depend on rainbow trout (the resident component), without a greater understanding of the underlying mechanisms (and degree of importance) for this dependence.

Similarly, a lack of historical data on adult abundance, combined with knowledge that the region's erratic streamflows were likely to produce highly variable run sizes that increase extinction risk, led to recommendations for a precautionary approach to adult abundance criteria as well. It was thought that better understanding of the mechanisms of environmental stochasticity in populations—especially the role of drought refugia—might eventually allow these criteria to be adjusted to a less precautionary stance.

Finally, as with ESA-listed salmon ESUs and steelhead DPSs in other NMFS recovery domains, it was recognized that population density was an important indicator of viability, but the specific life-stage and criterion for density were in need of further research. To promote further research, recommendations were made to replace these "prescriptive criteria" with more refined performance-based criteria over time as more information became available.[3]

For the two southernmost steelhead DPSs in California, viability criteria were defined in terms of collections of populations that each meet the population-level criteria, as well as additional criteria for geographic distribution and life-history expression. To meet criteria for geographic distribution within the two steelhead DPSs, a suite of viable populations would: (1) need to be distributed among the existing Biogeographic Population Groups (BPGs) within each DPS in numbers meeting criteria for representation and redundancy; (2) be located in drought refugia to mitigate against recurrent drought; and (3) be separated from one another by a minimum geographic distance to mitigate risk from wildfire, and related elevated sedimentation levels such as mud and debris flows. To meet the viability criteria for life-history expression, viable populations would need to consistently exhibit both the resident and anadromous life-history, as well as a third life-history of anadromous fish (lagoon-anadromous) that rear in estuaries for a significant time prior to smolting and emigration to the ocean.

1.2 Methodology used to complete the review

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

To complete the reviews, NMFS requested staff-scientists from NMFS' Northwest and Southwest Fisheries Science Centers to collect and then analyze new information about the viability of individual ESUs and DPSs. To evaluate viability of listed species of salmon and

[3] Prescriptive criteria identified specific targets, expressed in quantitative terms, while performance criteria identifies standards for final performance, expressed in theoretic terms.

steelhead, NMFS' scientists used the Viable Salmonid Population (VSP) concept developed by McElhany *et al.* (2000). The VSP concept evaluates four criteria—abundance, productivity, spatial structure, and diversity—to assess species viability.[4] Through the application of this concept, NMFS' 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 composition. At the end of this process, the science teams prepared reports detailing the results of their analyses.

In preparing this 5-year review for the South-Central California Coast Steelhead DPS, NMFS considered the best available scientific information, including the work of NMFS' Southwest Fisheries Science Center (SWFSC 2022), NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a), and related technical memoranda and reports prepared in support of the recovery plan, the listing record (including designation of critical habitat and adoption of protective regulations), recent biological opinions issued for the South-Central California Coast Steelhead DPS, information submitted by the public and other government agencies, and the information and views provided by NMFS' geographically based regional biologists. This 5-year review for the South-Central California Coast Steelhead DPS describes NMFS' 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

In 1997, NMFS listed South-Central California Coast Steelhead ESU under the ESA and classified it as a threatened species; in 2006, NMFS reaffirmed the species' listing as threatened under the joint USFWS/NMFS DPS policy. Table 1 provides a summary of the listing history for the threatened South-Central California Coast Steelhead DPS under the ESA.

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[4] A viable salmonid population is a population of Pacific salmon or steelhead (genus *Oncorhynchus spp.*) that has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and changes in genetic diversity (random or directional) over a 100-year time frame (Boughton *et al*. 2006). Specifically, a viable population should meet four viability thresholds for each of the four criterion types: mean annual run size, ocean conditions, population density, and the anadromous fraction; *see* Table 5 in Boughton *et al*. (2007).

Table 1. Summary of the listing history under the Endangered Species Act for the South-Central California Coast Steelhead DPS

Salmonid Species	ESU/DPS Name	Original Listing	Revised Listing(s)
Steelhead *O. mykiss*	South-Central California Coast Steelhead	**FR Notice:** 62 FR 43937 **Date:** 08/18/1997 **Classification:** Threatened	**FR Notice:** 71 FR 5248 **Date:** 01/05/2006 **Re-classification:** Threatened

1.3.3 Associated rulemakings

The ESA requires NMFS to designate critical habitat, to the maximum extent prudent and determinable, for species it lists under the ESA. Critical habitat is defined as: (1) specific areas within the geographical area occupied by the species at the time 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 a determination by the Secretary that such areas are essential for the conservation of the species. In 2005, NMFS designated critical habitat for the threatened South-Central California Coast Steelhead DPS within those areas occupied by the species at the time of its listing (70 FR 52488). Table 2 provides a summary of the rulemaking for 4(d) protective regulations and critical habitat for the endangered South-Central California Coast Steelhead DPS under the ESA.

At the time of the designation of critical habitat NMFS' Southwest Fisheries Science Center – Santa Cruz Laboratory had not mapped intrinsic potential steelhead over-summering habitat or completed its population characterization of the steelhead populations of south-central California (Boughton and Goslin 2006, Boughton *et al.* 2006); this information and analysis was, therefore, not reflected in the designation of critical habitat.

Section 9 of the ESA prohibits the take of species listed as endangered. The ESA defines take to mean harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. For threatened species, the ESA does not automatically prohibit take, but instead authorizes the agency to adopt regulations it deems necessary and advisable for species conservation and to apply the take prohibitions of Section 9(a)(1) through Section 4(d). In 2000, NMFS adopted 4(d) regulations for threatened salmonids that prohibit take except in specific circumstances (65 FR 42481). In 2005, NMFS revised the 4(d) regulations for consistency between ESUs and DPSs, and the Hatchery Listing Policy (70 FR 37159).

Table 2. Summary of rulemaking for 4(d) protective regulations and critical habitat for the South-Central California Coast Steelhead DPS

Salmonid Species	ESU/DPS Name	4(d) Protective Regulations	Critical Habitat Designations
Steelhead *O. mykiss*	South-Central California Coast Steelhead	**FR notice:** 70 FR 37159 **Date:** 06/28/2005 **FR notice:** FR 42422 **Date:** 7/10/2010	**FR notice:** 70 FR 52488 **Date**: 09/02/2005

1.3.4 Review History

Table 3 lists the numerous scientific assessments of the status of the South-Central California Coast Steelhead DPS. These assessments include status reviews conducted by NMFS' Southwest Fisheries Science Center – Santa Cruz Laboratory, and technical reports prepared in support of recovery planning for the South-Central California Coast Steelhead DPS.

Table 3. Summary of previous scientific assessments for the South-Central California Coast Steelhead DPS

Salmonid Species	ESU/DPS Name	Document Citation
Steelhead *O. mykiss*	South-Central California Coast Steelhead	Huber and Carlson 2020 Jarrett *et al*. 2019 Pearse *et al*. 2014, 2019 Garza *et al*. 2018 Swift *et al*. 2018 Arriaza *et al*. 2017 Williams et al. 2016 Boughton *et al*. 2016 California Department of Fish and Wildlife 2016 Holmes *et al*. 2016 U.S. Bureau of Reclamation 2015 Holmes *et al*. 2014 Williams *et al*. 2011 Boughton 2010c Clemento *et al*. 2009 Pearse and. Garza 2008 Garza and Clemento 2008 Boughton *et al*. 2007 Jackson 2007 Girman and Garza 2006 Boughton *et al*. 2005, 2006 Boughton and Goslin 2006 Helmbrecht and Boughton 2005 Good *et al*. 2005 Nielsen 1999 Nielsen *et al*. 1994, 1997a, 2001 Busby *et al*. 1996, 1997

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. These new guidelines superseded those in 55 FR 24296 issued in 1990. Under these guidelines, NMFS assign each species a recovery priority number ranging from 1 (high) to 11 (low). This priority number reflects the species' demographic risk (based on the listing status and species' condition in terms of its productivity, spatial distribution, diversity, abundance, and trends), and recovery potential (major threats, management actions 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, they are assigned a "C" and are given a higher priority over those species that are not in such conflict. Table 4 lists the recovery priority number (3C) for the South-Central California Coast Steelhead DPS that was in effect at the time this 5-year review began (NMFS 2019a). In January 2022, NMFS issued a new report with updated recovery priority numbers. The recovery priority number for South-Central California Coast Steelhead DPS remained unchanged (NMFS 2022a).

1.3.6 Recovery Plan

Table 4. Recovery Priority Number and Endangered Species Act Recovery Plans for the South-Central California Coast Steelhead DPS

Salmonid Species	ESU/DPS Name	Recovery Priority Number	Recovery Plans/Outline
Steelhead *O. mykiss*	South-Central California Coast Steelhead	3C	**Title:** South-Central California Coast Steelhead Recovery Plan Available at: https://www.fisheries.noaa.gov/resource/document/final-recovery-plan-south-central-california-steelhead **Date:** 2013 **Type:** Final **FR Notice:** 78 FR 77430

2. Review Analysis

In this section, NMFS reviews new information to determine whether the South-Central California Coast Steelhead DPS designation remains appropriate.

2.1 Delineation of species under the Endangered Species Act

Is the species under review a vertebrate?

DPS Name	YES	NO
South-Central California Coast Steelhead	X	

Is the species under review listed as a DPS?

DPS Name	YES	NO
South-Central California Coast Steelhead	X	

Was the DPS listed prior to 1996?

DPS Name	YES	NO	Date Listed if Prior to 1996
South-Central California Coast Steelhead		X	n/a

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

In 1991, NMFS issued a policy explaining how the agency would apply the definition of "species" in evaluating Pacific salmon 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 two criteria of: (1) being substantially reproductively isolated from other populations of the same taxonomic species; and (2) representing an important component in the evolutionary legacy of the biological species (Waples 1991, 1998, Waples *et al*. 2001; *see* also, Mayr 1942, 1962). The South-Central California Coast Steelhead DPS was originally defined and listed under NMFS' ESU policy in 1997 (61 FR 56139). The 1996 joint USFWS/NMFS DPS policy (61 FR 4722) affirmed that a stock (or stocks) of Pacific salmon and steelhead is considered a DPS if it represents an ESU of a taxonomically recognized species. Accordingly, NMFS considered the originally defined and listed ESU to be a DPS under the ESA. After reassessing the status of steelhead ESUs in 2005, NMFS decided to use the joint USFWS/NMFS DPS policy to define steelhead-only DPSs and in 2006 announced final listing determinations for steelhead based on the DPS policy (71 FR 834). That analysis concluded that the south-central California steelhead populations constituted a DPS under the DPS policy and that the DPS continued to be a threatened species.

2.1.1 Summary of relevant new information regarding delineation of the South-Central California Coast Steelhead DPS

DPS Delineation

This section provides a summary of information presented in the viability assessment for Pacific salmon and steelhead listed under the Endangered Species Act: Southwest (SWFSC 2022).

The South-Central California Coast Steelhead DPS is comprised of the anadromous component of *O. mykiss* complex of populations inhabiting coastal streams from the Pajaro River system south to but not including the Santa Maria River. Freshwater-resident (non-anadromous) *O. mykiss*, commonly known as rainbow trout, co-occur with steelhead in most of these coastal streams (Clemento *et al.* 2009), with which they sometimes interbreed (Pearse *et al.* 2019), but rainbow trout are not considered part of the ESA-protected South-Central California Coast Steelhead DPS (71 FR 834). Anadromous and non-anadromous forms of the genus *Oncorhynchus* exists in some watersheds (*e.g*., Rio Santo Domingo, Sierra San Pedro Mártir) in Baja, Mexico (Ruiz-Campos and Pister 1995, Nielson *et al*. 1997b, Nielsen *et al.* 1998, Miller 2005). Figure 1 depicts the South-Central California Coast Steelhead DPS, along with the minimum number of populations to be recovered in each BPG to meet the DPS-wide viability criteria. See the discussion below.

The South-Central California Coast Steelhead DPS was divided by Boughton *et al.* (2007) into 4 BPGs. See Figure 1.

- Interior Coast Range BPG consisting of populations in the Pajaro River and Salinas River (comprised of three subpopulations);
- Carmel River Basin BPG consisting of the Carmel River and its tributaries;
- Big Sur Coast BPG consisting of a series of short coastal watersheds, including San Jose Creek, Little Sur River, Big Sur River; and
- San Luis Obispo Terrace BPG consisting of a series of short coastal watersheds, including in the San Simeon Creek, Santa Rosa Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek.

No new information is available that would justify a change in the delineation or the population groupings (*i.e*., BPGs) of the South-Central California Coast Steelhead DPS (Boughton 2022 in SWFSC 2022).

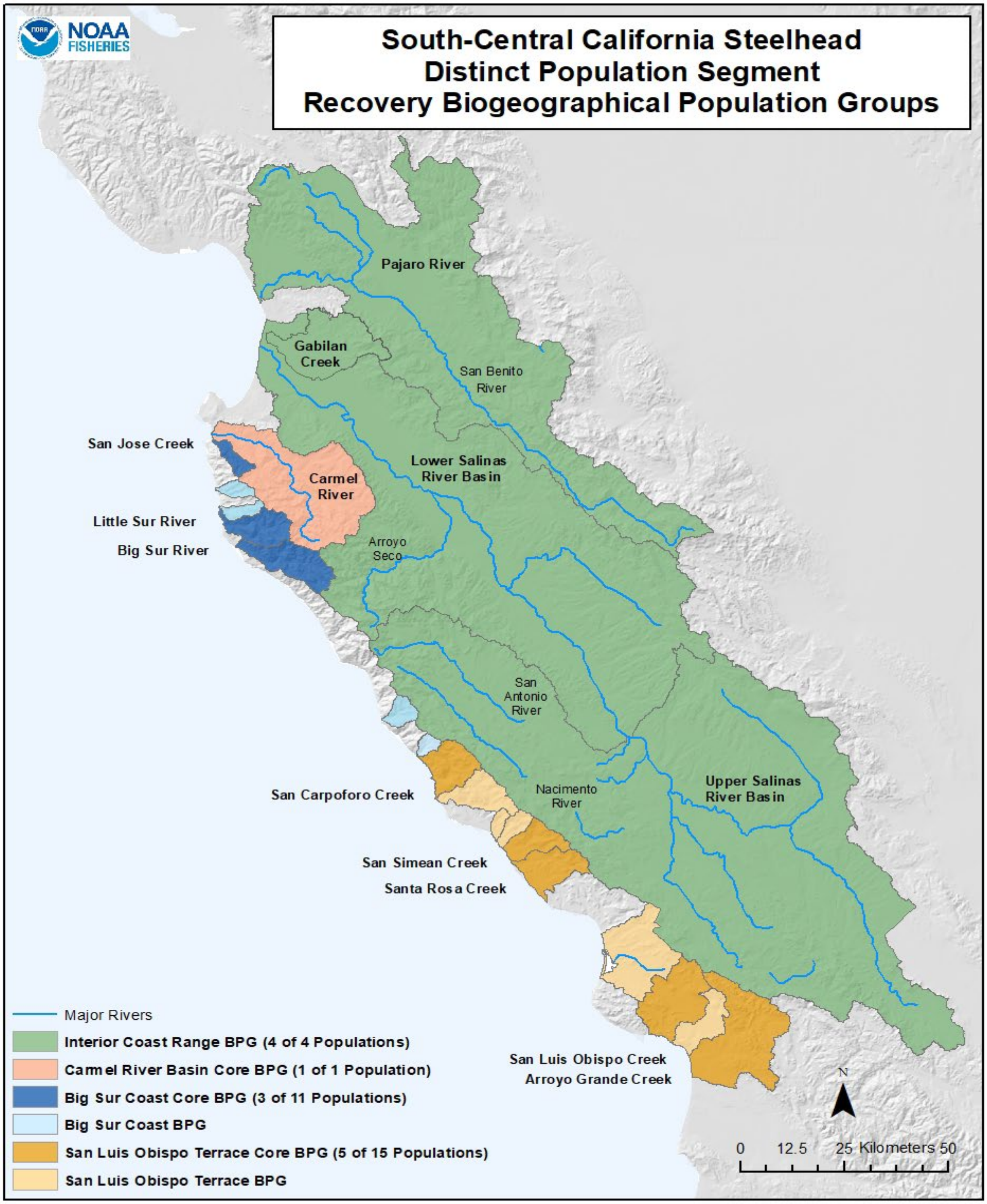

Figure 1. South-Central California Coast Steelhead DPS (and Biogeographic Population Groups): All naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable upstream barriers from the Pajaro River south to (but not including) the Santa Maria River (71 FR 834).

Membership of Hatchery Programs

In preparing the 5-year review, NMFS reviewed the available information regarding hatchery membership of the South-Central California Coast Steelhead DPS, and considered whether any relevant changes in hatchery programs or practices have occurred since the last 5-year review.

There are currently no steelhead hatchery programs within or serving the South-Central California Coast Steelhead DPS.

2.2 Recovery Criteria

The ESA requires the development of 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 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 four population viability metrics) and also of threats under the 5 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) (ii).

For Pacific salmon and steelhead, Technical Recovery Teams (TRTs) appointed by NMFS defined criteria to assess biological viability for each listed species. NMFS developed criteria to assess progress toward alleviating the relevant threats (listing factor criteria). NMFS adopted the TRT's viability criteria as the biological criteria for a recovery plan, based on the best available scientific information and other appropriate considerations. For NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a), NMFS adopted the viability metrics defined by the Technical Recovery Team for the South-Central/Southern California Recovery Domain (Boughton *et al*. 2007). These are the viability criteria (both for individual populations and the whole DPS for the threatened South-Central California Coast Steelhead DPS.

The TRT recognized that the listed South-Central California Coast Steelhead DPS—anadromous steelhead—were typically components of mixed populations of rainbow trout and steelhead, but the genetic, physiologic and ecological controls on the expression of these two life histories were poorly understood at the time of the listing. New research has improved understanding of the genetic architecture of *O. mykiss* populations exhibiting both non-anadromous and anadromous life-history forms. As a result, the 5-year review identifies a potential for refining the criterion for the anadromous fraction, defined as the proportion of reproducing adults that exhibit the anadromous life-history (Boughton 2022 in SWFSC 2022). See the additional discussion in Section 2.2.3 "The biological recovery criteria as they appear in the recovery plan" and "New Research Relevant to Population-Level Viability Criteria." For a detailed discussion of viability monitoring in the South-Central California Coast Steelhead Recovery Planning Area, see the recent update to the “California Coastal Salmonid Populations Monitoring (Adams *et al*. 2011), “Integration of Steelhead Viability Monitoring, Recovery Plans and Fisheries Management in the Southern Coastal Area” (Boughton *et al.* 2022).

As the South-Central California Coast Steelhead Recovery Plan (2013a) is implemented, additional information will become available, along with new scientific analyses, which can assist in recovery efforts. Additionally, this new information and understanding can increase certainty about whether the threats have been abated, whether improvements in population and DPS-wide viability have been achieved for the South-Central California Coast Steelhead DPS, and whether linkages between threats and changes in s viability are understood. NMFS assesses these biological recovery criteria and the delisting criteria through the adaptive management program for the plan during the ESA 5-year review (USFWS and NMFS 2006, NMFS 2020); *see* also, NMFS (2022a).

2.2.1 Approved Recovery Plan with Objective, Measurable Criteria

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

DPS Name	YES	NO
South-Central California Coast Steelhead	X	

2.2.2 Adequacy of recovery criteria

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

DPS Name	YES	NO
South-Central California Coast Steelhead	X*	

***See also the discussion and recommendation on monitoring the frequency of Omy5 “A” haplotype under “New Research Relevant to Population-Level Viability Criteria” and “Summary and Conclusions.”**

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

DPS Name	YES	NO
South-Central California Coast Steelhead	X	

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

For the purposes of reproduction, 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 populations that make up an ESU or DPS.

The threatened South-Central California Coast Steelhead DPS includes all naturally spawned anadromous *O. mykiss* (steelhead) originating below natural and manmade impassable barriers from the Pajaro River to (but not including) the Santa Maria River (71 FR 834). For recovery planning and development of recovery criteria, NMFS' Southwest Fisheries Science Center – Santa Cruz Laboratory identified discrete populations within the South-Central California Coast Steelhead DPS and grouped them into 4 BPGs: Interior Coast Range BPG, Carmel River Basin BPG, Big Sur Coast BPG, and the San Luis Obispo Terrace BPG.

NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) contains objective measurable recovery criteria based upon the viability criteria developed by NOAA's Southwest Fisheries Science Center – Santa Cruz Laboratory, and the recovery strategy developed by NOAA Fisheries' West Coast Region, and California Coastal Offices in Santa Rosa and Santa Barbara. NMFS' TRT identified two different approaches to articulating viability criteria: (1) prescriptive criteria, which identifies specific targets, expressed in quantitative terms, and (2) performance criteria, which identify standards for final performance, expressed in theoretic terms. Because of the uncertainties regarding populations of steelhead in the south-central California, quantitative prescriptive criteria must be precautionary, while performance criteria require the development of direct estimates of risk, and a quantitative account of uncertainty (Boughton *et al*. 2006, 2007); *see* also, Boughton (2010a, 2020b, 2010c). Table 5 provides a summary of "Viability Criteria for Steelhead in the South-Central California Coast Recovery Planning Area." A full discussion of these criteria is provided in Boughton *et al*. (2007) and NMFS (2013a).

Table 5. Viability Criteria for Steelhead in the South-Central California Recovery Planning Area

Criteria for Population Viability

Prescriptive Criteria:

Criterion	Viability Threshold	Notes
Mean Annual Run Size	S > 4,150	Precautionary
Ocean Conditions	Size criterion met during poor ocean conditions	
Population Density	Unknown	Research Needed
Anadromous Fraction	100% of 4,150	Precautionary

Criteria for Population Viability

Performance-Based Criteria:

One or more prescriptive criteria (above) could be replaced by a quantitative risk assessment satisfying the following:

1) Extinction risk of anadromous population less than 5% in the next 100 yr.
2) Addresses each risk that is addressed by the prescriptive criteria it replaces.
3) Parameters are either a) estimated from data, or b) precautionary.
4) Quantitative methods are accepted practices in risk assessment/population viability analysis.
5) Pass independent scientific review.

Criteria for DPS Viability

Criterion	Viability Threshold
Biogeographic Diversity	1) Sufficient numbers of viable populations in each BPG. 2) Viable populations in habitat watersheds in drought refugia.
Life history Diversity	3) Viable populations exhibit three life-history types (fluvial anadromous, Lagoon anadromous, freshwater resident)

NMFS 2013a

Population-Level Viability Criteria

The following describes the provisional prescriptive recovery criteria:

Mean Annual Run Size - Each population identified as a core population[5] within each of the 4 BPGs must meet the mean annual run size. In some cases, the population may be comprised of fish in two or more closely interacting watersheds. This numeric criterion is subject to modification pending further research, and could differ for individual populations based on further research. See Section 4.0 "Recommendations for Future Actions."

Ocean Conditions - Each population identified as a core recovery population within each of the 4 BPGs must meet the mean annual run-size during variable oceanic conditions over the course

[5] The recovery planning process (NMFS 2013a) indicates that while the threatened South-Central California Coast Steelhead DPS comprises several watershed-specific population units, only a few population units possess a high and biologically plausible likelihood of becoming *independently* viable. See Table 6. Populations within the Recovery Planning Area are identified as Core 1, Core 2, or Core 3 for the purposes directing recovery efforts. The Core 1 populations are those populations identified as the highest priority for recovery actions. Core 2 populations form a key part of the recovery implementation strategy and contribute to the set of populations necessary to achieve recovery criteria. Core 3 populations are an integral part of the overall biological recovery strategy by promoting connectivity between core recovery populations and genetic diversity across the DPS.

of at least six decades. In some cases, the population may be comprised of two or more populations from closely interacting watersheds. This criterion will require multi-decadal monitoring; currently, the monitoring of individual populations is inadequate to assess how they meet this criterion. See Section 4.0 "Recommendations for Future Actions."

Population Density - Each population identified as a core population within each of the 4 BPGs must meet the density criteria (currently unspecified pending further research). See Section 2.3 "Updated Information and Current Species' Status" for additional comments regarding low-flow freshwater density, and Table 8 regarding current low-flow freshwater fish density and trends in the South-Central California Coast Steelhead DPS.

Anadromous Fraction - The portion of each of the populations identified as a core population within each of the four BPGs that is counted towards meeting the population size criteria must be comprised of 100 percent anadromous individuals. In some cases, the population may be comprised of fish in two or more closely interacting watersheds. This numeric criterion is subject to modification pending further research. See the discussion in "New Research Relevant to Population-Level Viability Criteria."

New Research Relevant to Population-Level Viability Criteria

Life-history diversity is a critical component in the resilience of salmon and steelhead populations (Waples *et al*. 2001, Schindler *et al.* 2010, Waples *et al*. 2020, 2022, Capelli 2022). The South-Central California Coast Steelhead DPS includes only the anadromous members of this species (70 FR 67130). However, many steelhead populations along the West Coast of the U.S. can co-occur with sympatric non-anadromous *O. mykiss* (resident rainbow trout), and there may be situations where reproductive contributions from non-anadromous *O. mykiss* may mitigate short-term extinction risk for some steelhead DPSs (Good *et al*. 2005; 70 FR 67130).

Recent research has shed additional light on the relationship between the anadromous (sea-run) and non-anadromous (resident) forms of *O. mykiss* that bears on several aspects of the population viability criteria for the South-Central California Coast Steelhead DPS (Boughton 2022 in SWFSC 2022).[6] This work indicates that the tendency to out-migrate to the ocean (versus maturing in freshwater) is associated with particular juvenile body sizes, gender, the presence of a particular haplotype[7] on chromosome Omy5, and interactions between these and potentially

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[6] The taxonomic classification of anadromous and non-anadromous forms of *O. mykiss* in a single genus (*Oncorhynchus*) reflects a long-standing recognition of the close relationship between the two forms (Jordan and Gilbert 1882, 1892, Jordan 1888, Smith and Stearley 1989, Stearley and Smith 1993, Quinn 2018, Spence 2019, Behnke 2002fd). Additionally, recognition of the variable life-histories and polymorphisms of this single taxonomic species has long been recognized, though the genetic basis of this variation has only recently begun to be elucidated (Gunther 1880, Eigenmann 1890, Shapovalov and Taft 1954, Stearley 1992, Hendry *et al*. 2004, Hutchings 2004, Schaffer 2004, Pearse *et al.* 2014, 2019, Alagona 2016, Kelson *et al*. 2019); see discussion below.

[7] A haplotype is a set of closely linked alleles or other variations of DNA along a chromosome, or chromosome segment, which tend to be inherited together from a single parent.

other environmental factors (Martinez *et al*. 2011, Pearse *et al*. 2014).

Recent genetic analysis has revealed that sometime in the evolutionary history of *O. mykiss* a substantial portion of chromosome Omy5 underwent an inversion in which a segment of the chromosome was reversed end to end (Pearse *et al*. 2014, 2019). This inversion was passed onto progeny, but for fish in which one chromosome is inverted and the other not (*i.e*., a parent of each types), no crossing over (*i.e*., exchange of genetic material) can occur during the meiosis[8] phase of cell division, and so the set of genes on the inverted section of chromosome are tightly linked (*i.e*., prevented from mixing between the two types of genes that are inherited together from a single parent: haplotypes A – anadromous and R – resident. Figure 2 depicts the inverted region of chromosome Omy5 that has been found to be associated with the migratory behavior of *O. mykiss*.

Pearse *et al.* (2014) surveyed the occurrence of these two haplotypes—the original and reversed versions of Omy5 in coastal populations of *O. mykiss*—and found: (1) both Omy5 haplotypes were present in most populations; (2) strong evidence for natural selection on the set of linked genes within the inversion; and (3) one haplotype dominated at sites in anadromous waters (*i.e*., waters accessible to steelhead migrating upstream from the ocean), whereas the other was somewhat more common in non-anadromous waters at sites upstream of impassable barriers such as dams. Pearse *et al.* (2014) concluded that the two haplotypes appear to play some role in the genetic control of the expression of anadromy versus residency (steelhead versus rainbow trout) in *O. mykiss* of the California coast. Both Omy5 haplotypes (A and R) are broadly distributed throughout populations of the South-Central California Coast Steelhead Recovery Planning Area, but the frequency of the A haplotype has been negatively impacted by migration barriers, especially the complete barriers imposed by dams (Pearse *et al*. 2014, Apgar *et al*. 2017); *see* also, Abadía-Cardoso *et al*. (2011), Campbell *et al*. (2021).

In summary, both variants of the tightly linked Omy5 gene (sometimes referred to as a supergene) occur in most populations, but one variant tends to predominate in sites with connectivity to the ocean, and the other in populations without connectivity. Overall, these results show that the resident and anadromous forms of *O. mykiss* are closely integrated at the population level, suggesting a revision of the viability criterion for 100 percent anadromous fraction. However, such revision would require additional data derived from monitoring and quantitative analysis of population viability before criterion for the anadromous fraction could be modified. See the additional discussion below under “Anadromous Fraction”.

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[8] Meiosis is a type of cell division unique to germ cells in sexually reproducing organisms that reduces the number of chromosomes in the parent cell by half and produces four haploid gamete cells (sperm or egg cells). It involves two rounds of division that ultimately result in four cells with only one copy of each chromosome in which each chromosome has just one chromatid (one of two identical halves of a replicated chromosome).

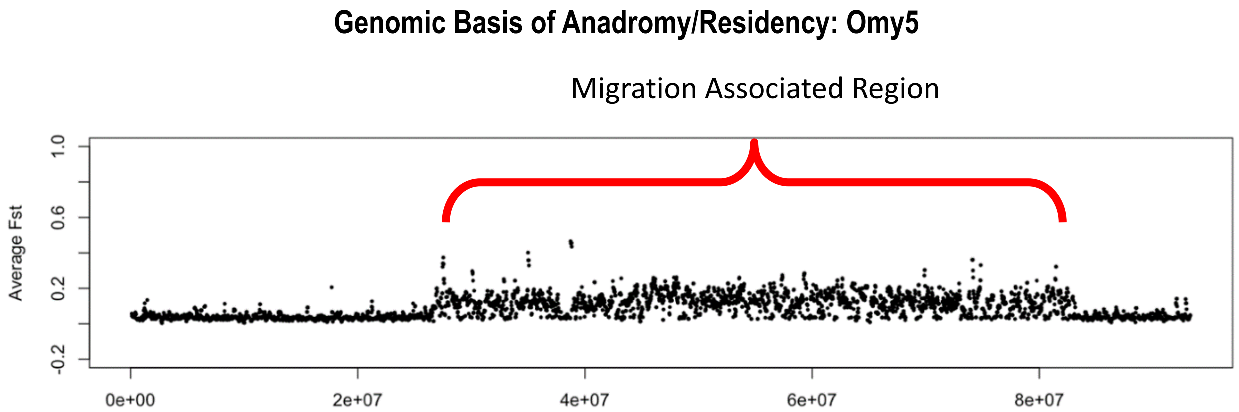

Figure 2. Massive double inversion complex of chromosome Omy5 > 50 million DNA base pairs, > 1000 genes. This complex acts as single locus, or supergene (adapted from Pearse, *et al.* 2019). Note: Fst represents the proportion of the total genetic variance contained in a subpopulation (with values ranging from 0 to 1).

Mean Annual Run Size - The original precautionary criteria for adult abundance relied on a simple model of density-independent population[9] fluctuations (Boughton *et al.* 2007). The basic idea was that the highly variable rainfall and streamflows characteristic of the region drove large fluctuations in adult abundance, and these fluctuations were as large, proportionally, when abundance was low as they were when it was high. This density-independence creates a high risk of a population fluctuating to zero; a relatively high population viability criterion for mean abundance is, therefore, required to compensate for that risk.

In contrast, if fluctuations in adult abundance were dampened when fish were rare, it would provide a stabilizing mechanism that would tend to protect against population extirpation, thus allowing a less stringent population-level viability criterion. Recent data collected in the Carmel River population (within the South-Central California Steelhead Recovery Planning Area) indicate that such density-dependent[10] dampening appears to occur and suggests a potential mechanism (Boughton and Ohms 2022a).

During the recent drought of 2012-2016, fish densities (juveniles + resident adults) in the mainstem Carmel River declined to very low levels. The drought was broken in 2017 by one of the wettest years on record, and data on steelhead densities were collected at random sites in the

[9] Density-independent populations are those in which any limiting factor can affect the size of the population regardless of the density of the population (*i.e.*, the number of individuals per unit area).
[10] Density-dependent populations are those in which regulating factors can affect the size of the population in combination with the density of the population; it is often expressed as a linear inverse relationship between population growth rate and population density (*i.e.*, population growth rate decreases as density increases and vice-versa).

fall of that year and in 2018 and 2019 (Boughton *et al.* 2020, 2022a). During the drought, abundance of adult steelhead declined to 0 fish in 2014 (inferred from failure of the sandbar at the mouth to open that year) and was likely very low through 2016, as judged by counts made at Los Padres Dam on the upper Carmel River. Adult counts from Los Padres Dam omit a substantial portion of the steelhead run—perhaps two thirds—but stayed at 0 through 2016 and were below 10 in 2017, suggesting consistently small run sizes overall. Figure 3 depicts the juvenile steelhead densities in the canyon, valley, and wet uplands section of the Carmel River at the end of the most recent drought from 2017-2019.

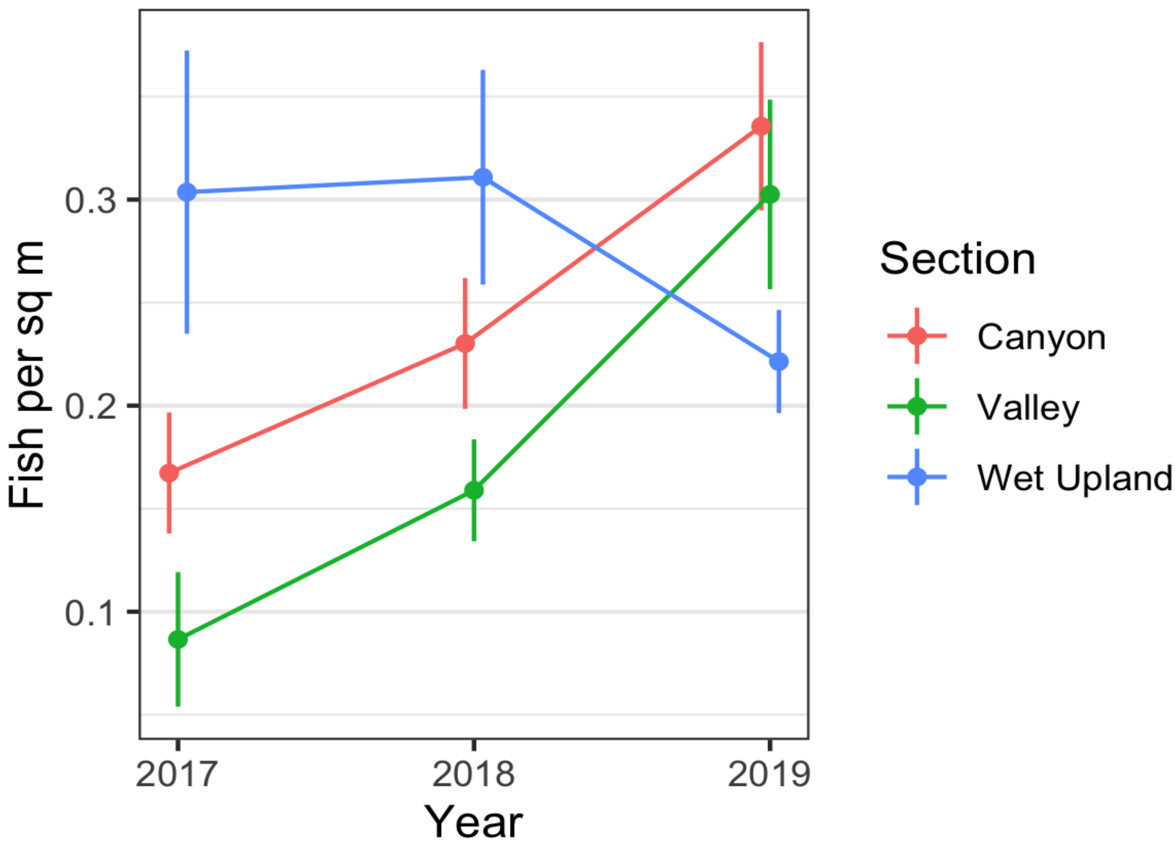

Figure 3. Dry-season juvenile steelhead densities in the Carmel River at the end of the recent drought, measured at random sites in the Valley section of the mainstem (estuary up to Tularcitos Creek), Canyon section of the mainstem (Tularcitos Creek to Los Padres Dam), and wet upland sites (southern tributaries and the headwaters upstream of Los Padres Dam). See Arriaza *et al.* 2017 and Boughton 2022 for additional details on the sampling methods used.

At the end of the most recent drought cycle in 2017, average fish density in the alluvial valley section of the mainstem was low (< 0.1 fish/m^2), but within 2 years had climbed to about 0.3 fish/m^2. This alluvial section of the river is vulnerable to heating and drying, which is likely the mechanism producing the low fish density observed in 2017.[11] Similarly, fish density in the canyon section of the river also emerged from the drought relatively low (though not as low as the valley section), and then rapidly climbed from 2017 to 2019. This section of river is regulated by flow releases from Los Padres Dam intended to sustain steelhead and is not as vulnerable to drying as the alluvial channel downstream; so, it is unsurprising that steelhead densities were maintained at higher levels than the valley section downstream.

However, the wet uplands—the upper Carmel River above Los Padres Dam, and other well-watered tributaries draining the heights of the Santa Lucia Mountains - apparently maintained even higher average fish densities than the canyon section of the mainstem, despite the fact that flows there are unmanaged. This suggests that during droughts, the distribution of *O. mykiss* tends to retract into the relatively reliable habitats at high elevations, where surface flow is sustained by orographic precipitation (or groundwater fed seeps and springs) and is also less vulnerable to being lost into large alluvial groundwater basins (or extracted for out-of-stream uses); *see* also, Brunke and Gonser 1997, Thomas and Famiglietti 2019. These findings suggest a mechanism by which population density becomes more stabilized at low abundance, by fish retracting into reliable drought refugia during periods of low-rainfall and re-expanding into less reliable downstream habitats after the drought ends. Thus, the density-independence assumption of the original precautionary viability criterion may be more stringent than necessary for populations with adequate and accessible drought refugia. Figure 4 depicts the density of juvenile steelhead in the Carmel River during the low-flow season as a function of the number of adult steelhead observed at the fish ladder on San Clemente Dam during the winter from 1996-2015.

Population Density - Population density criteria was proposed as an important risk metric by Boughton *et al*. (2007), but specifics of life-stages and criteria were left for further research. The original rationale was that a viable population should be characterized by good habitat conditions that sustain a population at high enough densities that density-dependent mechanisms for population stability come into play.

The only population in the South-Central/Southern California Recovery Domain with a sufficiently long data series and sufficiently variable densities to assess density-dependence is likely the Carmel River population. Arriaza *et al.* (2017) analyzed these data and found evidence for density-dependence in the juvenile life-stage during the summer low-flow season, when the amount of freshwater habitat (wetted area) shrinks to its minimum for the year. Figure 4 presents data from the Carmel River on mean fish density during the low-flow season, as a function of adult abundance the previous winter. The convex curved shape of the cloud of points illustrates the density-dependence found by Arriaza *et al*. (2017), and suggests that density-dependent

[11] Densities may also be influenced by greater hydrologic connectivity between the middle reaches of the watershed and the estuary, as well as the expanded distribution of adults throughout the watershed as a result of higher flows, that allow adults to access more of the watershed, rather than being limited to the middle reaches of the mainstem.

survival of *O. mykiss* is most prevalent above 0.30 fish per square meter of habitat (dashed line in Figure 4). This is very close to the mean value of 0.29 fish per square meter reported for trout in the "Pacific Forest" region (coastal mountains from Monterey County to U.S. border with Canada), in a meta-analysis of trout samples from the western U.S. during the middle of the last century (Platts and McHenry 1988). Thus, 0.30 fish/m^2 is an appropriate provisional population density viability criterion and is treated it as such in the status assessment of this 5-year review for the South-Central California Coast Steelhead DPS.

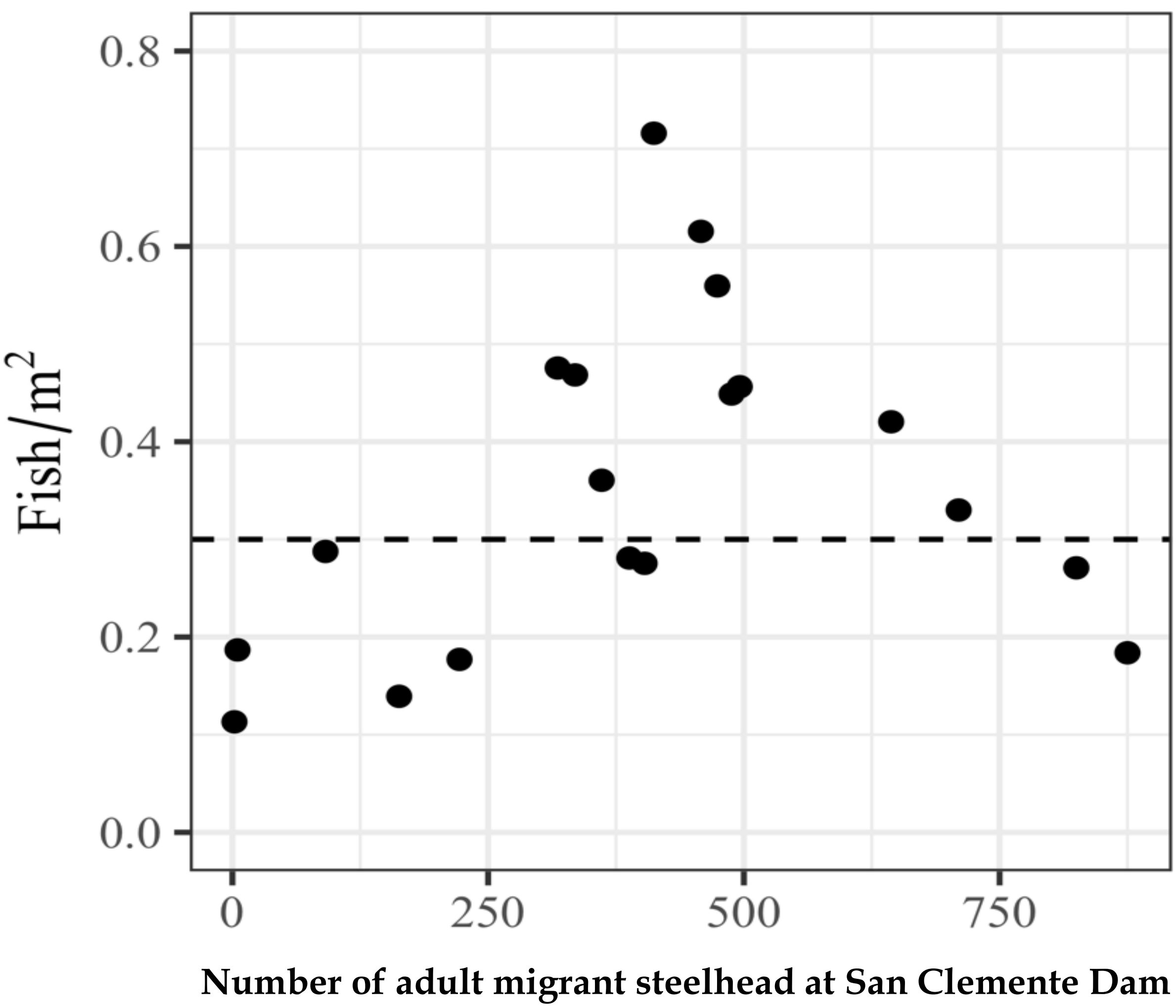

Figure 4. Juvenile O. mykiss density during low-flow season in the Carmel River, as a function of the number of adult steelhead observed the previous winter. Each point represents a year between 1996 and 2015, with densities the mean of ~10 index sites distributed across the valley and canyon sections of the mainstem (the "wet upland" section of the river system from Figure 3 was not monitored during this period). The x-axis is the number of migrant steelhead that ascended the fish ladder at San Clemente Dam (located in the middle reaches of the Carmel River until its removal in 2015). Note: this value represents an index of run size but is only a partial count due to undetected fish spawning downstream of the dam.

Anadromous Fraction - As noted, recent work has improved our understanding of the genetic architecture underlying mixed coastal *O. mykiss* populations of steelhead and rainbow trout. Building on the identification by Pearse *et al.* (2014) of two Omy5 haplotypes A and R associated with anadromy and residency, Pearse *et al.* (2019) delved more deeply in the genomic underpinnings of this association; Pearse *et al*. (2019) and Kelson *et al*. (2019) looked at associations with migratory behavior. Leitwein *et al*. (2017) and Apgar *et al.* (2017) examined environmental predictors for a high frequency of the A haplotype that is associated with anadromy.

The key findings with implications for the population-level viability criteria for the anadromous fraction are summarized below.

First, many of the genes in the inverted section of chromosome Omy5 are associated with circadian rhythms, sensitive to photosensory cues, the timing of age at maturity, and other traits associated with life-history variation (Pearse *et al*. 2019). As described earlier, genetic recombination among these different haplotypes can occur during the generation of homozygous RR fish and AA fish, but not during the generation of heterozygous AR fish due to the inversion. This feature allows the A and R haplotypes to adaptively diverge in response to selection for two distinct life-histories, while still being maintained together in the same population of *O. mykiss* (Pearse 2016; *see*, Campbell *et al*. (2021).

Second, the two kinds of inverted haplotypes (A and R) do, in fact, appear to be associated with different expression of life-history strategies (anadromous and resident). For example, Pearse *et al.* (2019) found that in a small steelhead population in Big Sur, juvenile *females* with the AA and AR genotypes were much more likely to migrate to the ocean than f*emales* with the RR genotype. Juvenile males with the AA and RR genotypes were similar to the females, but the *male* AR genotype was much less likely to migrate than the *female* AR genotype. This last observation is consistent with adaptive evolution of contrasting life-history strategies in males and females: female fitness is more associated with large body size than is *male* fitness, because of the energetic demands of manufacturing eggs versus sperm. Thus, *females* should be more likely than males to pursue anadromy because *O. mykiss* can generally achieve larger size at maturity in the ocean than in freshwater, and this provides more of a fitness benefit to females than to males (Pearse *et al.* 2019); *see* also, Rundio *et al*. (2012), Rundio *et al.* (2020), Harvey *et al*. (2021). In an independent study in the South Fork of the Eel River on the north coast of California, Kelson *et al*. (2019) made similar observations, finding that the expression of the downstream-migrant phenotype was associated both with being female *and* with having the A haplotype. In their smaller sample, they did not detect a difference in the migration rate of AR females versus AR males, but they did find that in general the migration frequency of the AR genotype was intermediate between the RR and AA genotypes.

Third, this intermediate life-history expression of the AR genotype has important implications for viability criteria - it provides a mechanism by which the steelhead life-history strategy can disappear from an *O. mykiss* population when environmental conditions are adverse (*i.e*., not conducive to migratory behavior) but re-express itself when conditions favor it (although the speed of this re-expression is uncertain). When conditions are adverse, the A haplotype may become rare enough that the occurrence of AA individuals are very unlikely, and the anadromous haplotype is maintained by *resident* fish carrying the AR genotype. Some of the progeny of such fish are AR rainbow trout that perpetuate the A haplotype in the resident population, whereas other progeny would be AR smolts that migrate to the ocean. These AR smolts would simply be lost because of mortality when conditions for anadromy are adverse (*i.e.*, fish are inhibited or prevented from emigrating to the ocean) but some surviving rainbow trout carrying the A haplotype could reconstitute steelhead runs when conditions for anadromy become favorable.

When favorable conditions persist, adult steelhead would become common enough to start producing AA individuals, and genetic recombination of the anadromous genome would resume and facilitate continuing adaptive evolution of the anadromous phenotype to changing environmental conditions. A resident-only population can probably not sustain the A haplotype indefinitely because the lost smolts produced by AR parents represent a fitness cost, though the loss appears to be a slow process. Apgar *et al.* (2017) estimated that the percentage of A haplotype in an isolated population loses about 5 percentage points per decade on average, although the loss would likely be faster initially and then slow down, and might be somewhat decelerated for watersheds in which the formerly anadromous fish can pursue their migratory life-history in reservoirs as an adfluvial population (Leitwein *et al*. 2017). A similar, reciprocal logic applies to the *resident* life-history, for example providing a mechanism by which AR steelhead could colonize vacant freshwater habitat that supports a population of rainbow trout when conditions for anadromy are adverse. Thus, even when the A haplotype is rare in a population, so that AA individuals are unlikely to occur, anadromy is still subject to natural selection due to its partial expression in AR individuals; and likewise for freshwater-residency and the R haplotype.

Fourth, the regional distribution of the two Omy5 haplotypes (A and R) across coastal populations is consistent with their link to migratory behavior. Throughout the California coast, subpopulations above and below dams are generally each other's closest relatives when viewed from the perspective of neutral genetic variation, but are highly divergent in their frequencies of the A and R haplotypes—the A haplotype is relatively common below dams, where fish have migratory access to the ocean, and R the haplotype is relatively more common above dams, where anadromous migrants cannot return to reproduce (Clemento *et al*. 2009, Pearse *et al.* 2014, Pearse *et al*. 2019).

For example, Apgar *et al*. (2017) examined haplotype frequencies in 39 steelhead populations in coastal California watersheds and found that frequency of the A haplotype at a sample site was associated with the site's degree of impact from migration barriers. Relative to similar sites without migration barriers, the frequency of the anadromous haplotype was most strongly affected by sites with complete barriers to anadromy that were longstanding. The strongest effect was associated with naturally occurring complete barriers, such as waterfalls: 31 percent effect when natural occurring barriers were present. The next strongest effect was associated with complete barriers that were more recently imposed (anthropogenic barriers): 18 percent effect when such barriers were present; followed by recent partial barriers: 2 percent per barrier, with the weakest effect from longstanding (natural) partial barriers: 0.5 percent per barrier. Additionally, migration distance itself (river kilometers between the sample site and the ocean) had a negative effect on frequency of the anadromous haplotype; but *see* also, Harvey *et al*. (2021). Overall, these five predictors explained 75 percent of the variation in the A and R haplotype frequency across the sites examined.

Leitwein *et al*. (2017) reported similar findings in San Francisco Bay-Area populations, where the A and R haplotype frequencies showed substantial evolutionary differences between the groups of fish above and below dams, despite the groups being each other's closest relatives. They also reported an important finding at a set of nine reservoirs, where the A haplotype was significantly more frequent in the group below the dam (71% versus 50%, $p < 0.05$), but more variable above the dam, where it was associated with the volume of the reservoir impounded by the dam (R^2=0.69, $p < 0.01$). This last observation suggests that the A haplotype can be maintained not only by access to the ocean, but also by access to a large reservoir with capacity to support a migratory behavior (referred to as an adfluvial life-history).

Fifth, although the A and R haplotypes are forms of adaptive genetic variation linked to anadromy and residency, respectively, they probably do not capture all the genetic variation associated with heritability of life-history strategies (Pearse 2016, Kelson *et al*. 2019). Moreover, the Omy5 haplotypes may also contain adaptive variation associated with other selected traits such as growth and maturation timing (O'Malley *et al*. 2003, Nichols *et al.* 2008, Rundio *et al*. 2020). Life-history strategies are also affected by environmental factors, especially as mediated by somatic growth and size-conditional smolting (Satterthwaite *et al*. 2009, 2012, Ohms *et al*. 2014, Kendall *et al*. 2015, Ohms and Boughton 2019). The mean size at which fish initiate downstream migration—that is, the way life-history strategy responds to environmental factors such as food availability—is itself subject to natural selection (Phillis *et al*. 2016). So, while there is a link between frequency of the A haplotype in a population and its expression of anadromy, numerous other genetic and environmental factors also play a role in its expression. However, since the A haplotype appears to be linked directly to migratory behavior itself, its presence would drive the selective environment experienced by the fish (freshwater vs. marine), which in turn drives the selection of other genes that adapt the fish to freshwater vs. marine environments, whether they are linked or not. To the degree that such adaptations are more successful than genes adapting the fish to the freshwater environment, the frequency of the A haplotype in the population will increase over time, and thus can be viewed as a lagging indicator for the viability of the anadromous form relative to the resident form of *O. mykiss*.

Sixth, the work of Apgar *et al*. (2017) and Leitwein *et al*. (2017) indicates that the frequency of the Omy5 A haplotype in populations is a useful indicator for the status of the steelhead DPS. Although juvenile fish with the AA or AR genotype may still adopt a resident life-history strategy, there is a probabilistic and functional association between the genotype and actual outmigration, and so the *frequency* of the A haplotype in a population is a lagging indicator for sustained past expression of the steelhead phenotype and its successful reproduction. Apgar *et al*. (2017) also suggested that the recovery potential of a population was indicated by the difference between the measured frequency of the A haplotype, and the frequency that would be expected based on predictive natural factors such as migration distance and occurrence of natural barriers. They viewed haplotype frequency is an indicator for both the recent past expression of anadromy, and the future potential expression of anadromy. Pearse (2016) observed that even though the life-history of individual fish cannot be inferred from the haplotypes and their constituent genetic alleles, in general "population-level inference based on the frequencies of specific . . . [adaptive alleles] could potentially be used to identify populations in which a particular trait [such as anadromy] is favoured"; *see* also, Funk *et al*. (2012). In short, the frequency of the A haplotype appears to be a useful broad-scale indicator of the degree to which the anadromous life-history strategy has been more favored by natural selection in the recent past. Because of the probabilistic association and the intermediate expression by the AR genotype, the indicator would be expected to change gradually, integrating selective effects over multiple generations of the fish (Apgar *et al*. 2017, Campbell *et al*. 2021). Thus, it seems likely to be a much less "noisy" indicator for anadromy than traditional annual counts of adult steelhead, which tend to fluctuate greatly from year to year.

Finally, Pearse *et al.* (2019) determined that the A haplotype is ancestral to the R type, even though the R haplotype is more broadly distributed geographically and is itself associated with anadromy in other regions (*e.g*., Pacific Northwest and Central Valley). After its initial appearance in a single population, it must have spread laterally to other populations via AR steelhead dispersing from their natal population to breed. This provided a mechanism for the parallel evolution of the resident phenotype across basins, in which natural selection operated on RR fish within basins, and the adaptations were moved laterally among basins by dispersing RA steelhead (Pearse 2016).

New research has documented dispersal of anadromous *O. mykiss* from their natal watersheds to non-natal watersheds (Donohoe, *et al*. 2021); *see* also, Donohoe (2007), Donohoe *et al.* (2008). These findings have implications for steelhead recovery and management within the South-Central/Southern California Recovery Domain. A study of a small coastal stream in the central portion of the South-Central Coast Steelhead DPS (Big Creek) revealed that of seven fish opportunistically sampled, all seven had dispersed from their natal watersheds. Three adults had originated from nearby streams (< 72 km) on the Big Sur coast, while three had originated from more distant rivers, including the Klamath River (680 km to the north). Significantly, of the seven dispersed individuals, one was the progeny of a non-anadromous female. The rate of dispersal from natal watersheds to non-natal watersheds could not be estimated based on the small sample size, but the study demonstrates that steelhead can: (1) disperse considerable distances and (2) nonanadromous females can produce anadromous progeny that can disperse considerable distances to non-natal watersheds (thus providing genetic connectivity among widely separated watersheds). This phenomenon could be an important mechanism for naturally re-colonizing steelhead habitats that have been de-populated as a result of either (or both) anthropomorphic modifications (*e.g*., construction of artificial barriers such as dams or road crossings) or natural environmental perturbations (*e.g*., wildfire, debris flows, droughts, or catastrophic floods); *see* Staley *et al.* (2020).

This resent research gives managers of West Coast steelhead a greater understanding of the way in which rainbow trout and steelhead mutually sustain each other and indicates that the precautionary criterion of 100 percent anadromous fractions could be refined. However, additional data needs to be gathered and analytical work needs to be conducted to identify what a new value would be for the anadromous fraction.

DPS-Level Criteria

NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) identifies the minimum number of core recovery populations within each BPG. These core recovery populations form the basis for the TRT's redundancy and resiliency recovery strategy; these BPGs must exhibit both biogeographic and life-history diversity. Figure 7 depicts the location of the core recovery populations within the South-Central California Coast Steelhead Recovery Planning Area. Table 6 identifies the total number of steelhead populations and the number of core recovery populations (arranged by BPG) necessary to meet the DPS-wide viability criteria for the threatened South-Central California Coast Steelhead DPS.

Biogeographic Diversity - A minimum number of viable populations must be distributed through each of the 4 BPGs. These viable populations must inhabit watersheds with drought refugia and be separated a minimum of 68 kilometers (km) to the maximum extent possible. NMFS' South-Central California Coast Steelhead Recovery Plan identifies a minimum suite of core recovery populations within each BPG, including those portions of the watersheds that contain drought refugia. See Table 5, bottom and Table 6 for the minimum number of recovered populations necessary for each BPG to achieve DPS viability. Further research is needed on this criterion, in particular the identification of drought refugia in the core recovery population watersheds (Boughton and Goslin 2006) See Section 4.0 "Recommendations for Future Actions."

Life-History Diversity - Each BPG must exhibit the three principal steelhead life-history types (fluvial-anadromous, lagoon-anadromous, and freshwater resident). The recovery plan identifies a suite of core recovery populations in each BPG with habitats having the intrinsic potential to support the three principal life-history types. New findings demonstrate that resident and anadromous life-histories in *O. mykiss* in the South-Central California Coast Steelhead Recovery Planning Area are tightly integrated. This in turn suggests that the viability criterion for a 100 percent anadromous fraction in core recovery populations could be revised based on further research. However, the studies summarized below do not include any population-viability analyses, which would be necessary for proposing a specific revision of the criterion. See additional discussion in Section 2.2.3 "New Research Relevant to Population-Level Viability Criteria."

The TRT recommends that all Core 1 and Core 2 populations meet the population-level biological criteria to achieve the minimum number of viable populations needed within each BPG. The following describes the combination of core recovery populations most likely to achieve viability for each BPG (NMFS 2013a).

Interior Coast Range BPG

The following Core 1 recovery populations must meet the four population-level viability criteria: Pajaro River, Lower Salinas River (including Arroyo Seco subbasin), Gabilan Creek, and Upper Salinas River (including San Antonio River, Nacimiento River and upper watershed tributaries).

Carmel River BPG

To achieve viable status, the Core 1 Carmel River recovery population must meet all four population-level viability criteria.

Big Sur Coast BPG

The following Core 1 recovery populations must meet the four population-level biological criteria as either single populations or a group of interacting trans-watershed population: San Jose Creek, Little Sur River, and Big Sur River. The following Core 2 recovery populations must meet the four population-level viability criteria as either single populations or a group of interacting trans-watershed population: Garrapata Creek and Bixby Creek. In addition, BPG viability could be further bolstered if the following Core 3 recovery populations promote connectivity between populations and genetic diversity across the BPG: Rocky Creek, Big Creek, Limekiln Creek, Prewitt Creek, Willow Creek, and Salmon Creek.

San Luis Obispo Terrace BPG

The following Core 1 recovery populations must meet the four population-level viability criteria, as either single population or a group of interacting trans-watershed population: San Simeon Creek, Santa Rosa Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek. The following Core 2 recovery populations must meet the four population-level viability criteria, as either a single population or a group of interacting trans-watershed population: San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Pico Creek, Morro Bay Estuary, Chorro Creek, and Los Osos Creek. BPG viability could be further bolstered if the following Core 3 recovery populations promote connectivity between populations and genetic diversity across the BPG: Villa Creek, Cayucos Creek, Toro Creek, Old Creek, and Morro Creek.

Table 6. Representation and Redundancy DPS-Level Criteria for Viable Populations within the South-Central California Coast Steelhead DPS

Biogeographic Population Group	Total Number of Populations	Number of Core Recovery Populations
Interior Coast Range	4	4
Carmel River Basin	1	1
Big Sur Coast	11	3
San Luis Obispo Terrace	15	5

NMFS 2013a

2.3 Updated Information and Current Species' Status

2.3.1 Analysis of Viable Salmonid Population (VSP) Criteria

Information provided in this section is summarized from the status assessment conducted by NMFS' Southwest Fisheries Science Center – Santa Cruz Laboratory (Boughton 2022 in SWFSC 2022) and provides an updated status assessment of populations within the South-Central California Coast Steelhead DPS since NMFS' 2016 5-year review.

Advances in Assessments and Related Research

The first comprehensive status review of steelhead was conducted by Busby *et al*. (1996), who characterized ESUs and assessed their extinction risk. Early molecular-genetic studies of coastal steelhead populations in California found genetic diversity to be highest in south-central and southern California (Nielsen *et al*. 1997), leading Nielsen (1999) to propose that the diversity was a signature for a Pleistocene refugium for the species in southernmost populations in California during the last ice age. Nielsen argued that this genetic diversity constituted a unique genetic legacy for the species (Nielsen *et al.* 2001), and presented data that it was being lost from hatchery populations (Nielsen *et al*. 1997). Relatively few sample sites were examined by Nielsen and the identification of ESUs by Busby *et al*. (1996) was based mainly on ecological factors, namely the shift from coastal redwood forest to coastal shrubland at the northern end of the original South-Central California Coast Steelhead ESU, and the shift in zoogeographic provinces at its southern end (coastal mountain ranges to transverse ranges; and the marine zoogeographic transition at Point Conception in southwestern Santa Barbara County).

At the time of the first status review (Busby *et al.* 1996), very few data had been collected on abundances, but those that existed suggested that anadromous adults had declined substantially. For example, current estimated annual run sizes from five major historic steelhead watersheds in south-central California (Pajaro River, Salinas River, Carmel River, Little Sur River, and Big Sur

River) were reported at < 100 in all but the Pajaro River, which was reported between <100 and < 1500, and the Carmel River, which was reported between >100s and 20,000. Additionally, the percentage of steelhead populations in three risk categories (No discernable decline, Declining, and Extinct) for the four south-central California coastal counties (Santa Cruz, Monterey, San Benito, and San Luis Obispo) suggested that a majority of the populations were either Declining or Extinct (Busy *et al*. 1996). The original review of Busby *et al*. (1996) was updated by Busby *et al*. (1997) and Good *et al.* (2005), Williams *et al.* (2011), and Williams *et al.* (2016); none of which led to changes in the threatened status of the South-Central California Coast Steelhead DPS. NMFS' published a South-Central California Coast Steelhead Recovery Plan in 2013 (NMFS 2013a).

After the pioneering genetic work of Nielsen and coauthors, subsequent genetic studies were able to examine larger numbers of neutral alleles in greater numbers of fish from a greater number of locations, and found that contrary to earlier findings, the genetic diversity in the southernmost California populations tended to be lower than in more northerly steelhead populations (Garza *et al*. 2014). Thus, the hypothesis of a Pleistocene refugium in south-central and southern California, with heightened genetic diversity and conservation value, was not supported by the new larger sample. However, overall genetic distance between populations, as determined by neutral genetic markers, was associated with geographic distance (either by river mile within basins or by coastal distance between basins), an example of the classic evolutionary pattern of isolation-by-distance. In addition, land-locked populations of *O. mykiss* upstream of impassible dams were found to have little genetic introgression from hatchery fish that had long been stocked in streams and reservoirs (to support a seasonal put-and-take fishery), and instead were more closely related to the wild anadromous *O. mykiss* populations immediately downstream of the dams (Clemento *et al.* 2009). However, for a variety of reasons, there has been a pronounced loss of native *O. mykis*s genotypes in the southernmost California steelhead populations (Abadía-Cardoso *et al.* 2016).

The pattern of isolation-by-distance in neutral genetic variation supported the concept of geographically structured ESUs, but the existing ESUs were based largely on ecological transitions did not tend to match up with the genetic breaks identified by Garza *et al*. (2014). In particular, a large genetic break occurred at the Golden Gate rather than at the transition from conifer forestlands to shrublands along Monterey Bay. Genetic samples from the early 20th Century, preserved in museum specimens, showed that prior to the extensive fragmentation of river systems by dams, the pattern of isolation-by-distance was even stronger (Pearse and Garza 2008, Pearse *et al.* 2011). These investigations have formed the foundation upon which subsequent research has been conducted into the population structure of southern populations of steelhead, the relationship between the anadromous and non-anadromous forms of *O. mykiss* and the implications for assessing the current status of the South-Central California Coast Steelhead DPS. See the discussion above on "New Research Relevant to Population-Level Viability Criteria", and the assessment below on "DPS –Wide Status and Trends", and core recovery populations.

Updated Biological Risk Summary

Additional information available on anadromous run size since Williams *et al.* (2016) remains limited but does not appear to suggest a change in overall extinction risk, with a few notable exceptions discussed below regarding the Carmel River. However, there is new information on genetics and the monitoring methodology relevant to viability criteria. The findings described previously for genetic architecture and anadromous fraction were based on data collected across both the South-Central California Coast and Southern California Steelhead DPSs, as well as the Central Coast Steelhead DPS, and appear to be broadly applicable to coastal steelhead populations in California (Pearse *et al*. 2019).

The risk of permanently losing the anadromous phenotype over the long term may be very high and likely increasing due to the lack of unobstructed migration corridors between upstream drought refugia and the Pacific Ocean; see the discussion of Donohoe *et al*. (2021) above.

However, the recent findings on the genetic architecture of anadromy show that the anadromous phenotype can be reconstituted from populations of rainbow trout in drought refugia if their gene pool contains the Omy5 A haplotype. Prior to the era of dam construction, this phenomenon of periodic local extirpation and regeneration of steelhead runs probably occurred naturally: rainbow trout populations in orographic and groundwater-supported drought refugia (perennial mountain streams) produced successful downstream migrants in years with sufficient rainfall to keep streams running to the ocean; and when enough of these "connection" years occurred with the right timing, the resulting adult steelhead returned and were then able to successfully ascend the streams to spawn and reproduce.

Unfortunately, a significant portion of the drought refugia that might help steelhead abundance rapidly rebound are currently above impassable barriers. For example, Santa Margarita Dam on the Salinas River, Nacimiento Dam on the Nacimiento River, and San Antonio Dam on the San Antonio River (all within in the Interior Coast Range BPG). In Carmel River BPGs, the Los Padres Dam impedes migration to important refugia habitat and in the San Luis Obispo Terrace BPG, Lopez Dam on Arroyo Grande Creek block access to the overwhelming majority of steelhead spawning, rearing, and refugia habitat in this Core 1 recovery population (NMFS (2013a). Moreover, in subpopulations isolated above impassable dams, the A haplotype appears to be adapting to reservoir conditions, and gene flow downstream (over the dams) may further erode the anadromous phenotype in downstream populations over time if the selective pressures for reservoir life are distinctly different than the selective pressures for the marine phase of the anadromous phenotype. Since the marine phase for anadromous phenotypes involves a rigorous migration along thousands of miles to a broad band of habitat in the north Pacific (Atcheson *et al*. 2012), and reservoir rearing of isolated populations does not, it seems likely that selective pressures are indeed quite relaxed in reservoirs versus the ocean, with negative consequences for long-term viability of the anadromous phenotype; however natural re-colonization of watersheds by the anadromous phenotype is also possible if migration corridors are re-established through the removal of anthropogenic barriers and restoration of migration flows; see the discussion of

Donohoe *et al*. (2021) above.

Recent work shows that the tendency to out-migrate to the ocean (versus maturing in freshwater) is associated with particular juvenile body sizes, sex, the presence of a particular inverted gene on chromosome Omy5, and interactions of these effects. Both variants (A and R) with inverted genes occur in most populations, but one variant tends to predominate in sites with connectivity to the ocean, and the other in populations without connectivity (Rundio *et al.* 2020, Harvey *et al*. (2021). As noted above, these results show that the resident and anadromous forms of *O. mykiss* are integrated at the population level, suggesting a revision of the viability criterion of 100 percent for the anadromous fraction. However, such revision would require additional quantitative analysis of population viability. See additional discussion above in "New Research Relevant to Population-Level Viability Criteria."

The results of recent monitoring efforts for both juvenile and adult steelhead is presented below. (Boughton 2022 in SWFSC 2022). This information forms the basis of the status assessment of the South-Central California Coast Steelhead DPS, and also provides the most recent data on individual core recovery populations that are the focus of recovery actions identified in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a).

DPS-Wide Status and Trends

Favorable conditions for anadromy in South-Central California Coast Steelhead DPS during the late 1990s briefly supported adult steelhead in the hundreds in the Carmel River. However, the recent drought extending of the past 5 years have reduced the successful recruitment of juvenile steelhead and size of adult runs of steelhead in all the core recovery populations within the South-Central California Steelhead Recovery Planning Area.

Population Biogeographic Population Group (BPG) Steelhead Abundances

Table 7 presents adult steelhead abundances for which available population data was reported in the 4 BPGs within the South-Central California Coast Steelhead Recovery Planning Area from 2000-2020.

Table 7. Adult abundance and trends in the Biogeographic Population Groups within the South-Central California Coast Steelhead DPS

Target of Estimation[1]	Yrs.	Full population estimate?	$\hat{S}$	Trend (SE)	p
Interior Coast Range BPG					
Salinas River[2]	6	No	0.25		

Target of Estimation[1]	Yrs.	Full population estimate?	$\hat{S}$	Trend (SE)	p
Carmel River Basin BPG					
Los Padres Trap[3]	20	No	9	-0.105 (0.025)	0.0007
Big Sur Coast BPG					
Big Sur River	5	No	42		
SLO Terrace BPG[4]		No			

[1] Target of estimation is the stream system for which estimates were made. Yrs. is the number of years having data. Full population estimates as reported by CDFW for partial versus full estimates of the target. $\hat{S}$ is the average number of adult steelhead per year for the most recent four years; trend is the regression line fit to log-transformed annual runs.

[2] Data covers the period 2011-2017; no data was reported for 2015, or 2018-2019; also, an assessment of the full run season was possible only in some years, but not others. $\hat{S}$ was estimated from most recent four years of available data. The weir used in this population estimate was not fully operable during migration periods, and no redd surveys were conducted.

[3]Counts at the Los Padres fish trap at the base of Los Padres Dam omit approximately two-thirds of the Carmel River steelhead run, which spawn below the Los Padres Dam.

[4]No data was reported from 2015 through 2022 from the San Luis Obispo Terrace BPG, though limited monitoring has been conducted in several watersheds.

Table 8 presents the density of freshwater juvenile steelhead trends for which available data was reported in the 4 BPGs within the South-Central California Coast Steelhead Recovery Planning Area from 2000-2020. In none of the watershed did the reported density meet or exceed 0.30 fish/m^2 that has been provisionally identified as a potentially appropriate new population density viability criterion. See the density discussion above in “New Research Relevant to Population-Level Viability Criteria”, and below for each of the 4 BPGs.

Table 8. Low-flow freshwater fish density and trends in the South-Central California Coast Steelhead DPS

Target of Estimation	Yrs.	Density Unit	Density	Trend (SE)**	Dw occ***	Occ****
Uncalibrated Electrofishing						
Interior Coast Range BPG						
Upper Pajaro Tribs[1]	0	1D*	0.183	-0.0256 (0.0090)	-	-

Target of Estimation	Yrs.	Density Unit	Density	Trend (SE)**	Dw occ***	Occ****
Calibrated Electrofishing						
Interior Coast Range BPG						
Lower Pajaro Tribs.	14	2D*	0.232	-0.0234 (0.0121)	0.232	1.0
Carmel River Basin BPG						
Lower Carmel River	20	2D	0.183	-0.0271 (0.0091)	0.183	1.0
Big Sur Coast BPG						
Big Creek	15	2D	0.258	-0.0173 (0.0074)	0.258	1.0
No Data Reported						
San Luis Obispo Terrace BG						

Boughton 2022 in SWFSC 2022
[1] Uvas Creek and one of its tributaries.
* 1D densities are fish per meter or stream channel during the low-flow season; 2D densities are fish per square meter of wetted area.
** Trend is estimated as the slope parameter from a linear regression of log10 (density) on ye year. Proportional level at p<0.05 and p<0.01
*** Density of species within occupied (*i.e.*, mean density omitting reaches where species was not observed)
**** Proportion of occupied habitat

Biogeographic Population Group (BPG) Level Abundance

An updated summary of current monitoring efforts and results is presented below, arranged by the BPGs delineated in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) and based on the Southwest Fisheries Science Centers – Santa Cruz Laboratory viability assessment of the South-Central California Coast Steelhead DPS (Boughton 2022 in SWFSC 2022).

Here we report data indicating adult returns and abundance of juvenile steelhead during the dry season low-flow period for steelhead populations within each of the BPGs of the South-Central California Coast Steelhead DPS. These populations are a reasonable representation of the entire DPS because they include both small coastal watersheds as well as larger inland watersheds, geographically span the DPS, and involve most of the Core 1 recovery populations while including Core 2 and 3 recovery populations as well. (Boughton 2022 in SWFSC 2022).

Interior Coast Range BPG

This Biogeographic Population Group (BPG) consists of the Pajaro River population and three populations in the Salinas River basin: the Gabilan Creek, Arroyo Seco, and southern Salinas populations. Figure 5 depicts the trends in anadromous adults for populations of the South-Central California Coast DPS, compiled from various sources by CDFW (2020). The abundance of adult steelhead has not been monitored in the Pajaro River. The combined run of the 4 populations in the Salinas River basin (but not including Gabilan Creek) has been monitored intermittently since 2011 (Monterey County Water Resources Agency 2014a, 2014b, 2014c, 2014d, 2014e, 2014f); unfortunately, the California Department of Fish and Wildlife (CDFW) reports that no data have been recorded since 2017 (CDFW 2020) and the time series is too short to estimate a trend. Run sizes here have been extremely small, always less than 50 fish per year and sometimes zero. Figure 5 depicts the trends in anadromous adults for three populations of the South-Central California Coast DPS (Big Sur River, Carmel River, and Salinas River. The missing data from 2015 for the Salinas River can probably be interpreted as a zero count: the fish counter was not operated because the lagoon never opened during this drought year. See bottom of Figure 5 for trends in anadromous adults in the Salinas River. It is conceivable that anadromous fish entered the river via the Old Salinas River Channel, though unlikely; however, adult Chinook salmon were reported caught by anglers the year the bar did not open (J. Casagrande, personal communication). If anadromous fish did enter the river via the Old Salinas River Channel, access to suitable spawning and rearing habitat was not available due to lack of flow in the lower 30 miles of the river (USGS Salinas River: Spreckels Gauge 1152500, Chualar Gauge 1152300).

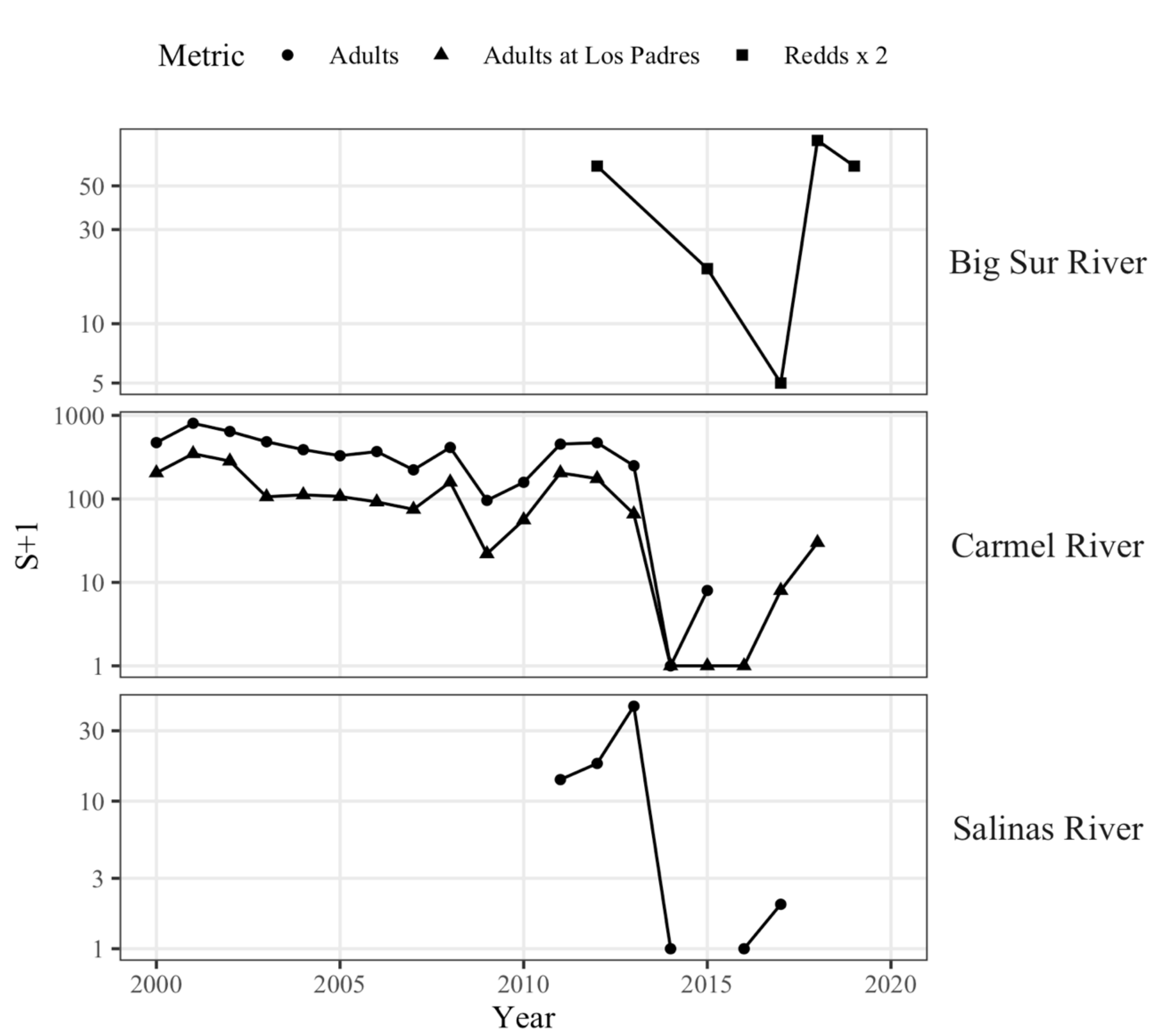

Figure 5. Trends in anadromous adults for populations of the South-Central California Coast DPS, compiled from various sources by CDFW (2020). In the Carmel River, round symbols show counts at San Clemente Dam, which was removed in 2015; triangles show concurrent and continuing counts at the Los Padres Dam fish trap upstream of the former San Clemente site (Boughton 2022 in SWFSC 2022).

Assuming that the count in 2015 was zero, the average run size for the most recent four years ($\hat{S}$) was only 0.25 steelhead for the three Salinas populations combined. See Table 7. CDFW (2020) rates the Salinas counts as full population estimates, except for 2011 and 2017 when operation of the Vaki fish counter was temporally limited. Based on observations of lagoon closure and opening, the operators of the fish counter inferred that adult steelhead may enter the estuary months before the upstream migration (e.g., the prior fall) or even mature in the estuary (Cuthbert et al. 2014a, 2014b, 2020).

Figure 6 depicts the low-flow densities of juvenile steelhead in the lower Pajaro River, lower

Carmel River, and Big Creek. Fish densities during the low-flow season were collected at 6 to 10 sites per year in lower Pajaro tributaries by Beck *et al.* (2019), using calibrated electrofishing. See Figure 6A for lower densities in the lower Pajaro River. The average density dipped below 0.3 fish/m^2 for 5 years during drought, but had recovered above this threshold as of 2019; the average density for the most recent four years was still below the threshold at 0.232 fish/m^2. See Table 8 above.

Upper Pajaro tributaries were monitored by Casagrande (2015, 2016, 2017, 2018, 2019, 2020, 2021); *see* also, D.W. Alley & Associates (2013, 2015a, 2015b, 2019), using uncalibrated electrofishing; since wetted widths were not reported 1-dimensional densities (1D; fish per meter of channel) are presented in Figure 6B, with 1D densities of the lower Pajaro included for comparison in Figure 6A. Only the upper Pajaro densities showed a statistically significant downward trend ($p < 0.05$; Table 8 above). All these mean densities were derived from index sites rather than a random sample of sites, so their representativeness is subjective. Nevertheless, these data show relative trends—in years with higher precipitation and streamflow, when juvenile abundance improves as access to interior tributaries improves. Despite data being collected largely by single pass electrofishing with no calibration, the trend and patterns are overall similar to the other rivers within the BPG.

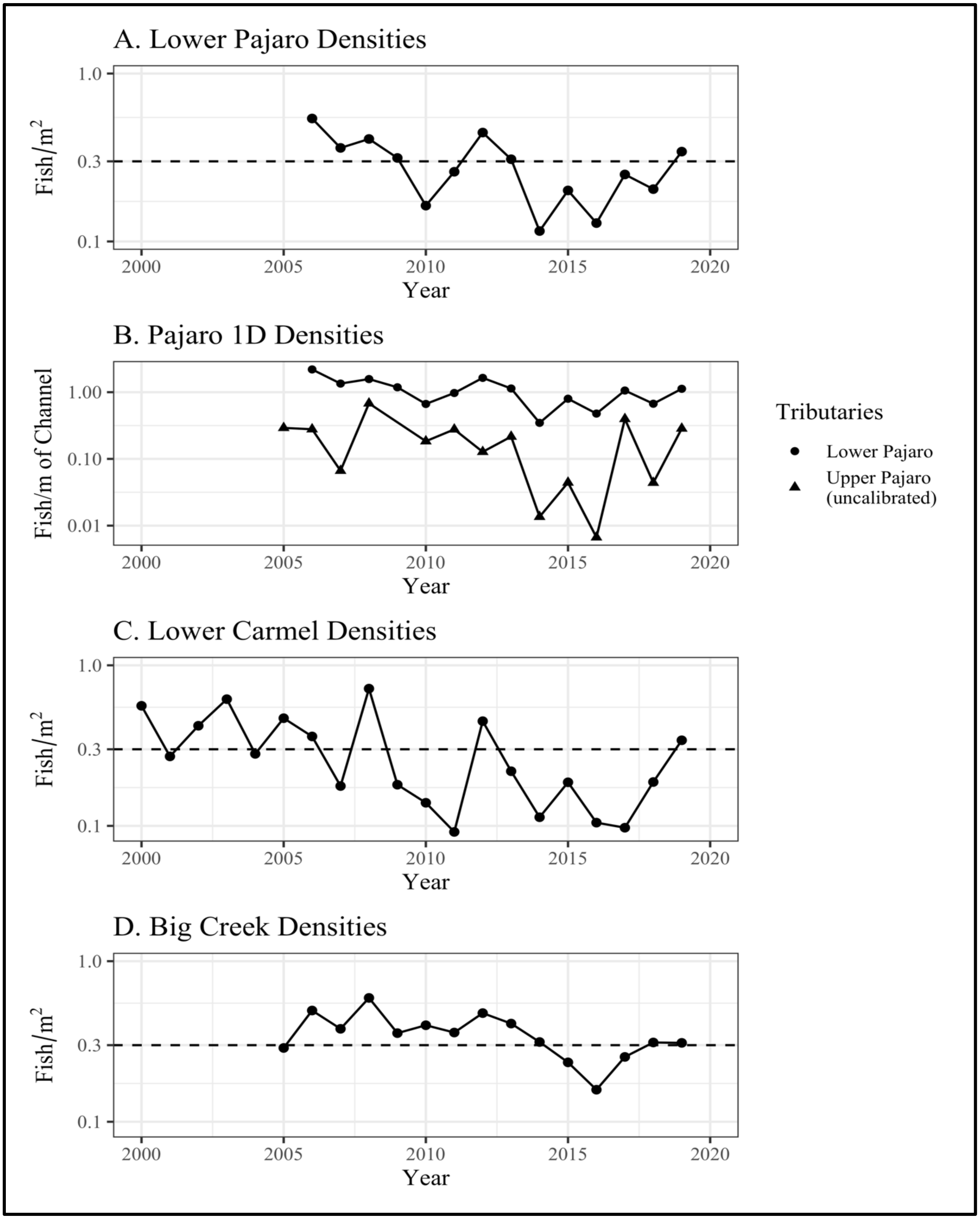

Figure 6. Low-flow densities of juvenile steelhead in the South-Central California Coast DPS. Densities are calibrated electrofishing estimates (depletion estimates) except for the upper Pajaro, which are from single-pass electrofishing (Boughton 2022 in SWFSC 2022).

Carmel River Basin BPG

Abundance of anadromous adults has been monitored for decades in the Carmel River at fish-passage facilities at two dams, San Clemente Dam and Los Padres Dam (Monterey Peninsula Water Management District 2014, 215, 2016, 2017, 2018, 2019a, 2019b, CDFW 2020). The more complete counts at the lower dam (San Clemente) terminated in 2015 with the removal of the dam. Both series are partial counts due to steelhead spawning downstream of the dams; and both are illustrated in Figure 6 for completeness. While non-anadromous adults were observed at Los Padres Dam for three years during the drought, adults have been observed since the end of the drought in 2017 and the removal of San Clemente Dam in 2015. See Figure 5. For the past 20 years there has been a significant downward trend averaging -21 percent per year ($p = 0.0007$), and despite the recent uptick the mean run size of the past four years is only 9 adults. See Table 7.

Fish densities on the mainstem Carmel have been monitored for over 20 years at about 10 index sites distributed between the Los Padres Dam and the estuary. Prior to 2009, the mean density was usually above 0.3 fish/m^2 but from 2009 onward, it only exceeded this threshold in two of eleven years, 2012 and 2019. See Figure 6C. This created a statistically significant downward trend ($p < 0.01$; *see* Table 8) averaging -6 percent per year. The average density of the most recent four years was 0.183 fish/m^2, which is below the proposed population viability criterion. Note that this status and trends analysis omits the drought refugia in the upper watershed and southern tributaries, which were not monitored until 2017.

Big Sur Coast BPG

Abundance of anadromous adults has been reported intermittently for the Big Sur River since 2012 (CDFW 2020), but the series is too short to estimate a trend. See Figure 5. The average run size of the most recent four years of data was 42 fish, although these data were not considered to be full population estimates by CDFW (2020). The criterion for representation and redundancy specifies four Core recovery populations in Big Sur Coast BPG, suggesting that three additional core recovery populations should be established and monitored for adult abundance.

Fish density has been reported for the steelhead population in Big Creek over the past 15 years (Rundio and Lindley 2008; T. Williams, personal communication; D. Rundio, personal communication. Densities here have been relatively stable, staying above 0.3 fish/m^2 except for three years at the end of the drought. See Figure 6. Even so, this pattern created a statistically significant downward trend ($p < 0.05$), averaging -4 percent per year. The average density for the most recent four years captured the end-of-drought nadir at 0.258 fish/m^2. See Figure 6D, Table 8.

San Luis Obispo Terrace BPG

No data series have been reported by CDFW (2020) for the San Luis Obispo Terrace BPG, which has a viability criterion of 5 core recovery populations with viable numbers of adult steelhead. See Table 8.

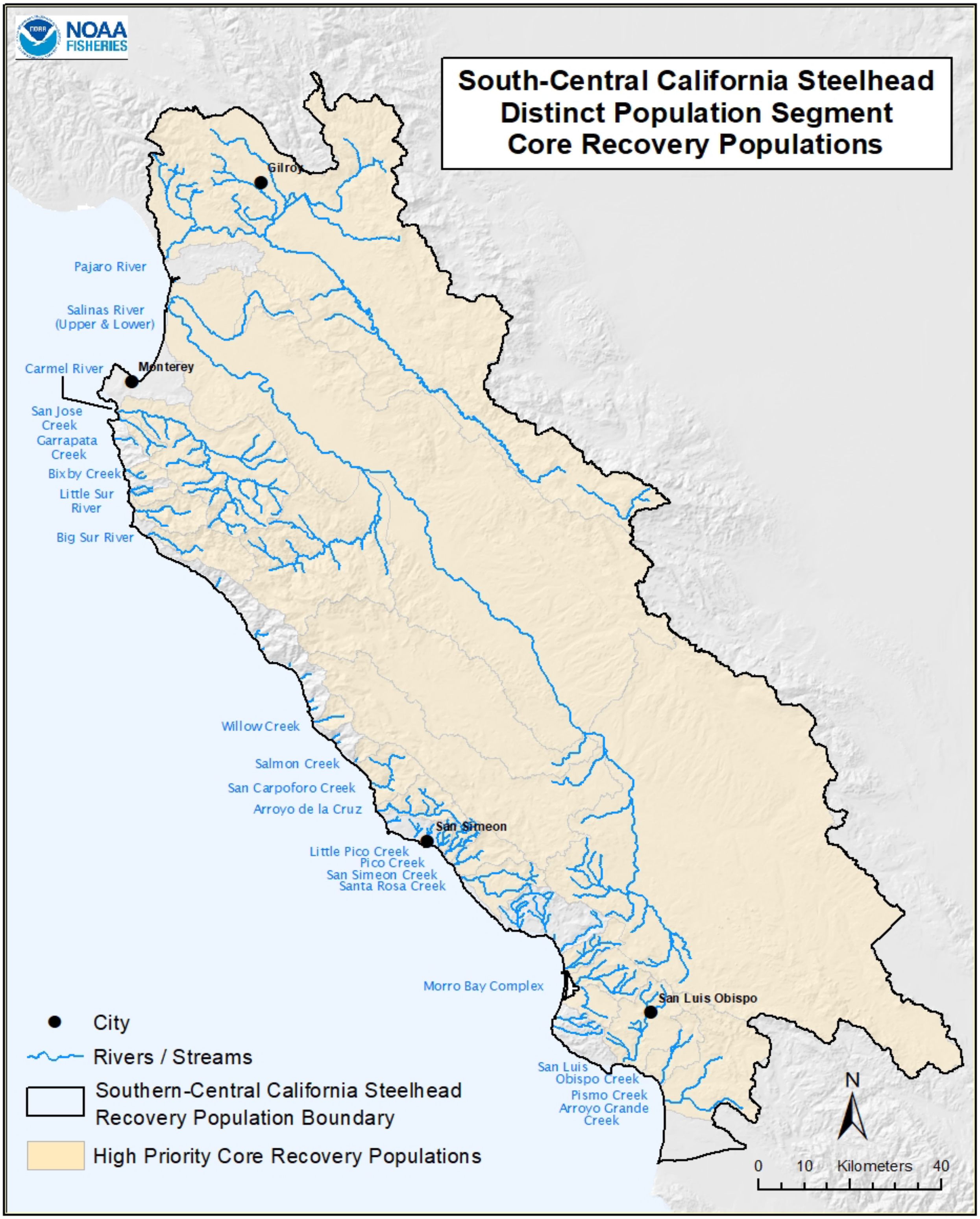

Figure 7. Core Recovery Populations within the South-Central California Coast Steelhead Recovery Planning Area.

Summary and Conclusions

Data on current adult abundances and low-flow fish densities both indicate that the recent drought had very large negative impacts on the DPS, with generally negative trends observed in all indicators, most with statistical significance. See Table 3 and Table 6. However, since the end of the drought in 2017 all indicators have ticked upward), suggesting that *O. mykiss* populations have persisted in drought refugia (*e.g*., lower Pajaro River tributaries, the upper Carmel River, the Big Sur Coast) and are now recovering from the drought; *see*, for example, Podlech (2019). Yet the size of steelhead runs is extremely low, and the mean fish densities for the past four years are still below the provisional viability criterion of 0.3 fish/m^2. We do not know the frequency of AA genotypes in these populations. See Figures 6 and 7 and Table 8 for specific low-flow densities of juvenile steelhead in selected core recovery populations.

For long-term viability of the steelhead phenotype, populations will need periods where the anadromous fraction is high enough that AA fish occur in sufficient numbers to allow genetic recombination while buffering against genetic drift. We see no evidence for such conditions since the turn of the 21^{st} Century, when anadromy was common in the Carmel population. Thus, even though the A haplotype provides a mechanism for the anadromous phenotype to weather droughts via rainbow trout, its continuing adaptive evolution appears to be curtailed and the viability of the anadromous phenotype thus remains at high and increasing risk; *see* also, Campbell *et al.* (2021).

Because of the functional association between the Omy5 A haplotype and outmigration, the frequency of the A haplotype in populations uninfluenced by reservoirs can be used as a lagging indicator for sustained past expression of the steelhead phenotype and thus to identify populations where it is being favored by natural selection (Pearse 2016, Funk *et al*. 2012). Apgar *et al*. (2017) inferred that when environmental conditions are completely adverse to anadromy over extended periods, the percent of A haplotypes in a population declines by about 5 percentage points per decade, and this gives some sense of the timescale for the loss of genetic capacity for anadromy. While the frequency of the A haplotype in a population can be viewed as a lagging indicator of successful anadromy in the past, the frequency of AA (*i.e*., homozygous) fish can be seen as an indicator for the possibility of continuing adaptive evolution in the present, which supports expression of the anadromous phenotype over the long term.

Monitoring of status and trends continues to be unsatisfactory within the South-Central California Coast Recovery Planning Area. A draft plan to update the monitoring strategy (Boughton *et al*. 2022b) has been subject to an extended review process in an attempt to resolve the various ecological and methodological factors that complicate and impede effective monitoring. The main features of this up-dated monitoring strategy are:

- Estimates of mean 2D density[12] in core recovery population for each BPG;
- Data revealing the location and extent of drought refugia in core recovery populations in each BPG;
- Estimates of adult steelhead abundance in selected populations, sufficient to evaluate BPG and DS-wide representation and redundancy;
- Estimates of adult rainbow trout abundance, sufficient to evaluate total abundance of adult *O. mykiss* in core recovery watersheds within the South-Central California Steelhead Recovery Planning Area;
- Addition of routine genetic monitoring, to track occurrence and frequency of the Omy5 A haplotype in core recovery populations within each BPG as indicators for viability; and
- Estimates of smolt production and marine survival in selected core recovery populations.

The effectiveness of habitat restoration actions and progress toward meeting the viability criteria should also be monitored and evaluated with the aid of newly developed monitoring and evaluation programs. Generally, it takes multiple decades to demonstrate increases in viability, and this timeframe must include a sequence of average or above average rainfall years to provide migratory opportunities necessary to support the marine/freshwater life-history of anadromous *O. mykiss* (Boughton *et al.* 2006, 2007); *see* also, Boughton *et al.* (2022b).

Despite current limited monitoring activities, enough has been learned over the past 5years to begin to refine viability criteria for abundance, anadromous fraction, and population density for this DPS. However, additional field and analytic work is needed to develop new risk-based viability criteria to refine the precautionary criteria. There is now also a better understanding of the underlying genetic architecture that allows runs of steelhead to decline to zero during adverse conditions for anadromy, and then be reconstituted by populations of rainbow trout surviving in drought refugia when conditions improve.

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

[12] 2D density refers to fish per square meter of wetted channel during the low-flow season when base flow conditions prevail. This density metric may be good indicator for the population density that was originally proposed, but left undefined, in NMFS' TRT Technical Memorandum (Boughton *et al*. 2007) and NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a). Table 8 presents the low-flow freshwater density trends available for the South-Central California Coast Steelhead DPS.

existing regulatory mechanisms; or (E) other natural or man-made factors affecting its continued existence. Section 4(b)(1)(A) requires NMFS to make listing determinations solely on the basis of the best scientific information and commercial data available after conducting a review of the status of the species and taking into account efforts to protect such species. Efforts to protect species are considered pursuant to the joint NMFS/FWS Policy for Evaluation of Conservation Efforts When Making Listing Determinations (68 FR 1500). As noted in the introduction section above, however, a 5-year review is not a re-listing or justification of the original (or any subsequent) listing action. Below we discuss new information relating to each of the five listing factors as well as efforts to protect such species.

Listing Factor A: Present or Threatened Destruction, Modification or Curtailment of the Species Habitat or Range

For most of California, the recent drought ended in 2017. Figure 8 shows the record of annual precipitation for three important orographic drought refugia for steelhead in coastal California south of the Golden Gate. In all three refugia, the drought commenced in 2012, but for the refugia in the Central Coast (Ben Lomond Mountain) and the South-Central Coast (Ventana Double Cone), annual precipitation returned to nearly average in 2016, and broke the drought in 2017.

Consideration of rainfall amounts is important because steelhead are only able to express their full life-history traits, which confer a survival advantage to the anadromous form of the species, when the characteristics and condition of their freshwater habitat is conducive to survival, growth, and emigration of smolts to the ocean; *see*, for example, Arriaza (2015). Varying amounts of rainfall provide different degrees of properly functioning habitat condition and the amount and availability of living space for juvenile steelhead during the dry season. Higher rainfall amounts generally also provide greater migratory opportunities for both adult and juvenile migrants. Little to no substantial rainfall often leads to reduced availability, or entire loss, of suitable over-summering habitat (dry season refugia) for juvenile steelhead and, therefore, fewer juveniles reaching the smolt stage and contributing to adult returns and reproduction. Given the below average rainfall amounts since 2016, the habitat characteristics and conditions were not generally supportive of steelhead growth and survival in south-central California.

The recent findings of the genetic architecture underlying anadromy provide a mechanism by which the anadromous life-history strategy can be sustained over time, but also suggest that ongoing adaptation of the anadromous phenotype is inhibited by its chronic low expression in recent years. While favorable conditions for anadromy in the late 1990s briefly supported adult steelhead in the hundreds in the Carmel River, abundances of adult steelhead in the South-Central California Coast Steelhead DPS have been consistently low for many decades. This implies an increasing risk of permanent loss of the anadromous life-history phenotype in some core recovery populations.

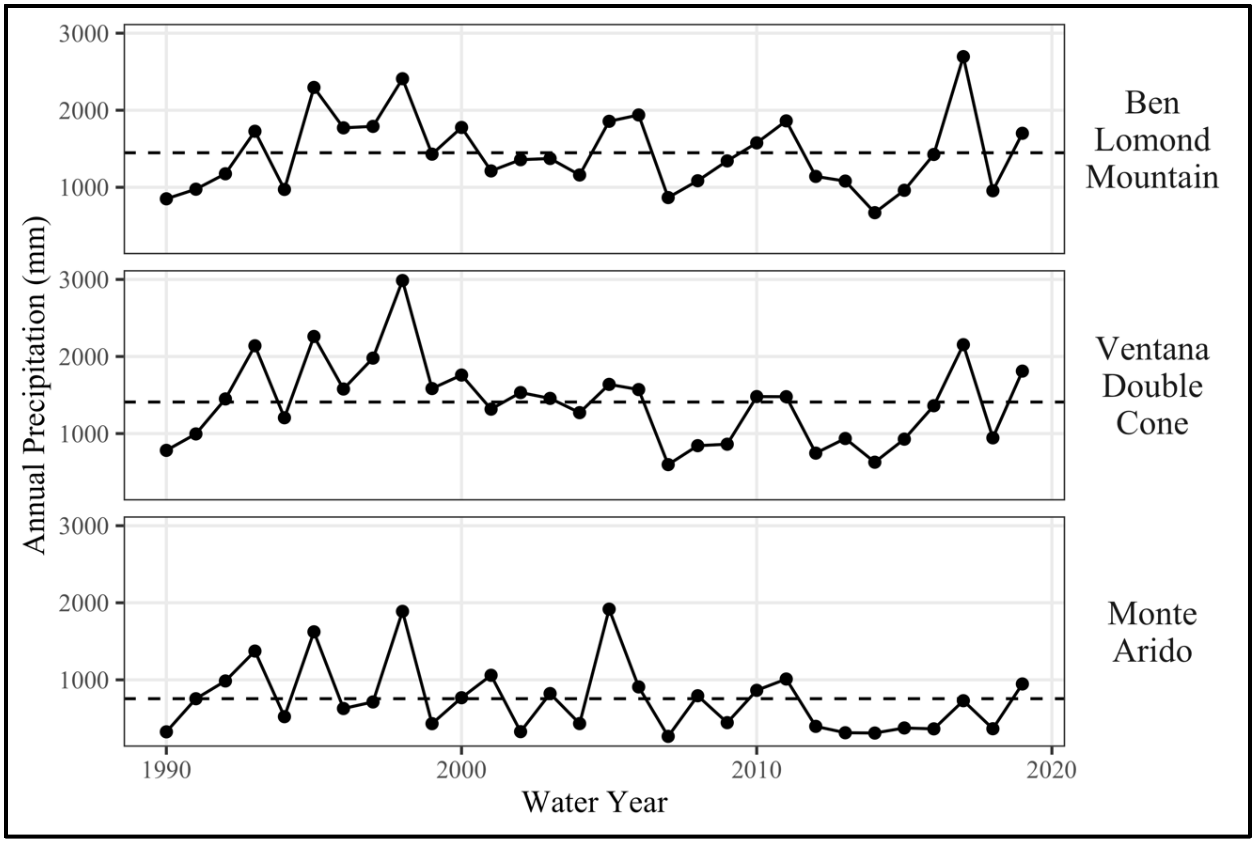

Figure 8. Thirty years of annual precipitation for three orographic drought refugia on the California coast south of the Golden Gate, arranged north to south. Ben Lomond Mountain supports the Scott, Waddell and San Lorenzo steelhead populations in the Central Coast DPS; Ventana Double Cone supports the Carmel, Big Sur and Little Big Sur populations in the South-Central California Coast Steelhead DPS; and Monte Arido supports the Santa Maria, Santa Ynez and Ventura populations in the Southern California Steelhead DPS. Dashed lines represent the 30-year mean for each site; values are PRISM climate reconstructions (https://prism.oregonstate.edu/) for the 4-km grid-cell containing each mountain peak (Boughton 2022 in SWFCS 2022).

Significant habitat restoration and protection actions at the federal, state, and local levels have been implemented to improve the degraded habitat conditions and fish passage issues described in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a); *see* also. Schmidt (2020), Kocik *et al*. (2022). While these efforts have been substantive and are expected to benefit the survival and productivity of the core recovery populations, there is not yet evidence demonstrating that improvements in habitat conditions have led to improvements in population viability. Figure 9 depicts the recently constructed concrete free-span vehicular bridge over Santa Rosa Creek.

The effectiveness of habitat restoration actions and progress toward meeting the viability criteria should be monitored and evaluated with the aid of newly developed monitoring and evaluation programs. Generally, it takes multiple decades to demonstrate increases in viability, and this time-frame must include a sequence of average or above average rainfall years, and long-term oceanic cycles, necessary to support the freshwater/marine life-history of anadromous *O. mykiss* (Boughton *et al*. 2007).

Figure 9. This vehicular bridge over Santa Rosa Creek on Ferrasci Road replaced an at-grade, culverted road crossing that impeded fish passage. Santa Rosa Creek is a Core 1 watershed within the San Luis Obispo Terrace BPG. Photo: Bobby Jo Close, San Luis Obispo County.

The prolonged drought began in 2012 and ended in 2017, but re-commenced and continued through 2021 (Seager *et al*. 2015, Luo *et al.* 2017, Ullrich *et al.* 2018). The drought, with only a few average or slightly above average rainfall years interspersed during this period, has adversely impacted both anadromous and resident *O. mykiss* populations. These conditions have reduced migration and spawning opportunities for adult steelhead as well as rearing and emigration opportunities for juveniles. Many watersheds have experienced complete desiccation of stream sections that normally have perennial flows (or pools sustained by groundwater), and this desiccation has persisted over multiple years, resulting in a substantial reduction in the amount and quality of spawning and rearing habitat for steelhead in south-central California. Barrier bar-built estuaries are naturally closed a majority of the year, but estuarine sandbars have been closed more frequently and for longer periods (or breached for only brief periods) during the recent drought, thus limiting the opportunities for upstream migration of adult steelhead and emigration of juveniles to the ocean, as well foraging opportunities for juveniles (Jacobs *et al.*

2011, Rich and Keller 2011, 2013, Largier *et al.* 2019). See the discussion of "General Status and Trends" in Section 2.3 "Updated Information and Current Species' Status."

Multiple wildfires have occurred in most of the BPGs within the South-Central California Coast Steelhead Recovery Planning Area, affecting many of the core recovery watersheds. See Figures 10, 11, 12, 15, and 16. Wildfires are an integral part of the natural physical processes that create and serve to maintain both terrestrial and aquatic habitats in the Mediterranean climate, and chaparral dominated landscape characteristic of the South-Central California Coast Steelhead Recovery Planning Area (Keeley and Zedler 2009, Keeley *et al.* 2012, Coombs and Melack 2013, Scott *et al*. 2014, Keeley and Syphard 2016, 2017, Borchert and Davis 2018, Scott 2018, Pyne 2021). See Figures 10 and 11. Figure 10 depicts the total number and distribution of recorded wildfires in south-central California: 1950-2019, with the greatest number of fires occurring along the Big Sur Coast. Figure 11 depicts the effects on coastal sage scrub and conifer vegetation in the Big Creek watershed (Big Sur Coast) following the 2020 Dolan Fire.

However, natural patterns of wildfire (timing, intensity, frequency, geographic extent, *etc*.) have been modified by short and longer-term climatic changes (particularly droughts), and by anthropogenic interventions, including ignitions and firefighting methods and strategies. Wildfires are likely to increase in frequency, intensity, and extent as a result of a variety of factors, including increased human ignitions, vegetation type conversions, and climate changes (Jensen and McPherson 2008, Westerling and Bryant 2008, Bryant and Westerling 2009, Dietrich *et al*. 2014, Westerling 2016, Abatzoglou and Williams 2016, Andela *et al.* 2017, Bendix and Commons 2017, Keyser and Westerling 2018, McLauchlan *et al*. 2020, Parks and Abatzoglou 2020, Pyne 2021, Rehmann *et al*. 2021).

The effects of wildfires are diverse and complicated, and can be both beneficial and deleterious to steelhead and steelhead habitats. Adverse effects can be pronounced in tectonically active and semiarid environments such as south-central and southern California (Swanson 1981, Shakesby and Doerr 2006, Dunham *et al*. 2007, Keeley *et al*. 2012, Cooper, *et al*. 2013, 2015, Dietrich *et al*. 2014, Florsheim *et al.* 2017, David *et al*. 2018, Goodridge *et al*. 2018, Keeley and Syphard 2018, Kibler *et al*. 2019, McLauchlan *et al*. 2020, Cooper *et al.* 2021).[13]

[13] For monthly updates on fire-related publications, *see* "Current Titles in Wildland Fire" published by the Fire Research Institute: www.firerearchinstitute.org.

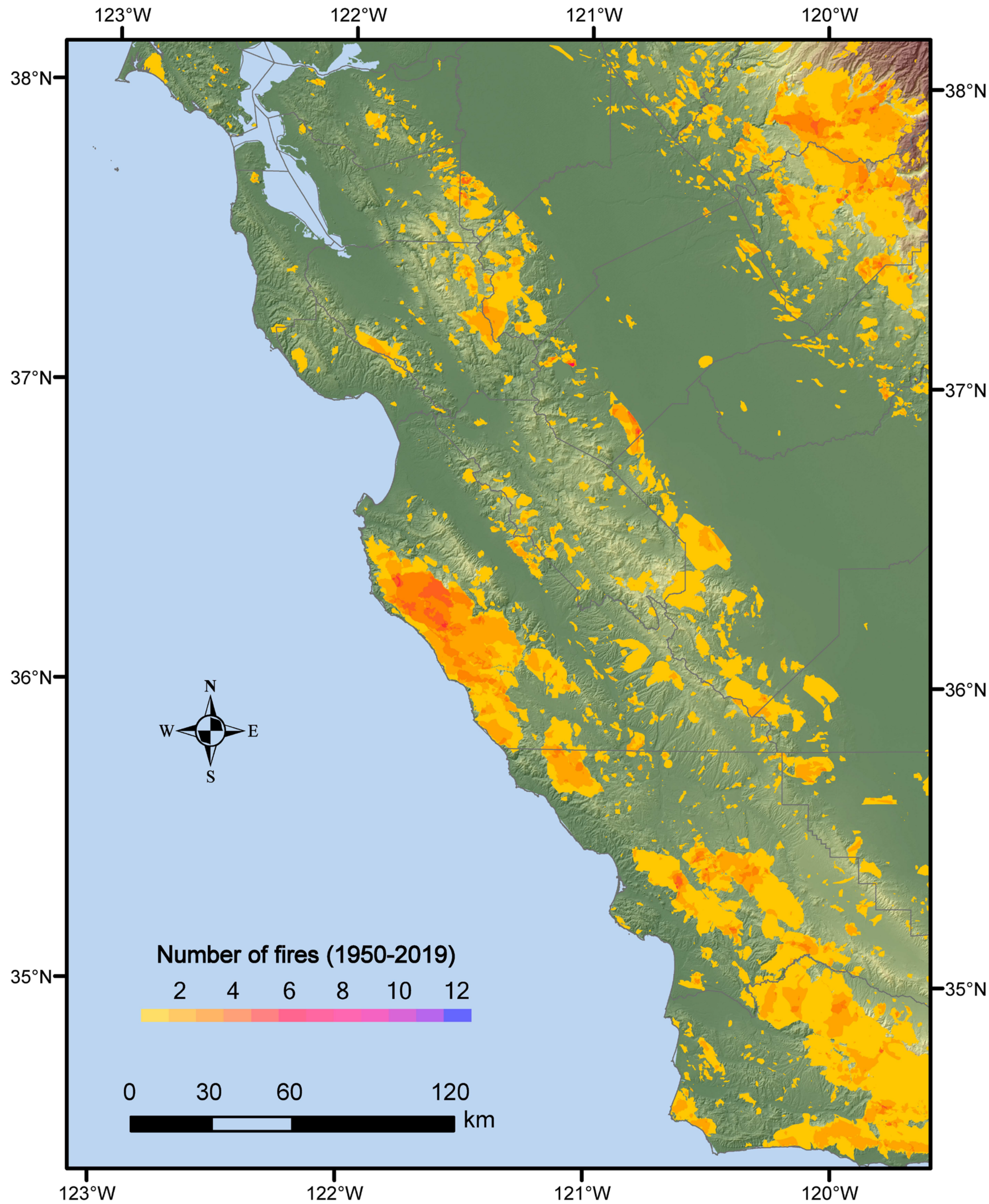

Figure 10. Total number of recorded wildfires in south-central California between 1950-2019. (Courtesy of C. Dong, Sun Yat-sen University and Southern Marine Science and Engineering Guangdong Laboratory, Zhuhai, China)

Figure 11. Big Creek Watershed looking north along the Big Sur Coast showing the extensive loss of vegetative cover, including coastal chaparral and conifers, caused by the 2020 Dolon Fire. The Dolon Fire burned c. 90 percent of the Big Creek watershed, along with significant portions of the watersheds of San Antonio River and Nacimiento River (tributaries to the Salinas River), Monterey County. August 22, 2020. Photo: Mark Readdie, University of California, Santa Cruz.

Some of the more significant adverse effects to steelhead habitats caused by wildfires, particularly those which are exacerbated by anthropogenic activities include, but are not limited to: (1) increases in slope erosion and sedimentation of water courses (including riffles and pools) leading to loss of spawning, rearing, and refugia habitat; (2) modification of run-off patterns (including higher peak flows, but also in some cases sustained base flows because of reduced evapotranspiration); (3) changes in the water temperature regime as a result of both reduction or loss of riparian vegetation and stream discharge (and associated reduced dissolved oxygen levels); (4) alternation of nutrient transport and loading within watercourse (affecting both instream vegetative growth and invertebrate production); (5) spread of non-native, invasive vegetation (which may affect both evapotranspiration rates and invertebrate production important to rearing juvenile steelhead); and (5) firefighting techniques, such as the use of fire retardants and physical modifications of the landscape to create temporary or permanent fire breaks (Coffman *et al*. 2010, U.S. Forest Service 2011, Cooper *et al*. 2012, Verkaik *et al*. 2013, Dietrich *et al.* 2014, Coombs and Melack 2015, Cooper *et al.* 2015, Klose *et al*. 2015, Florsheim *et al*. 2017, NMFS 2018a, 2018b). See Figures 10, 11, 12, 14, 16, and 17.

Figures 12, 14, 16, and 17 depict the extent of selected wildfires experienced within the South-Central California Steelhead Recovery Planning Area since 2016, and the debris flow potential estimated by the United States Geological Survey (USGS) from a design storm[14] within the perimeter of the respective wildfires.

Current Status and Trends in Habitat

Information on the *current status and trends in habitat* conditions is summarized below, arranged by BPG. This 5-year review specifically addresses: **(**1) the *key emergent or ongoing habitat concerns* (threats or limiting factors) focusing on the top concerns that potentially have the most significant adverse 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 protective measures and major restoration actions* taken since the 2016 5-year review toward achieving the recovery plan viability criteria adopted in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) as efforts that substantially address a key concern noted in above #1 and # 2, or, that represent a noteworthy conservation strategy; (4) *key regulatory measures that are inadequate* and underlay the key concerns summarized above; and, (5) *recommended future recovery actions* over the next 5 years toward achieving population viability**,** including: key near-term restoration actions that would address the key concerns summarized above; projects to address monitoring and research gaps; fixes or initiatives to address inadequate regulatory mechanisms, and addressing priority habitat areas when sequencing priority habitat restoration actions.

Interior Coast Range BPG

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

- Dams without fish passage provisions such as San Antonio Dam, (on San Antonio River, tributary to the Salinas River), Nacimiento Dam (on Nacimiento River, tributary to the Salinas River), and Santa Margarita Dam (on the upper Salinas River). Pickell Dam (on Little Arthur Creek, tributary to Pajaro River) can pass fish but still impedes volitional fish passage.

[14] A design storm is a rainfall event with an intensity of 24 mm/hr. for 15 minutes (equivalent to 6 mm of rainfall accumulation over a 15 minute interval). For many parts of California, the 24 mm/hr., 15 minute scenario is roughly equivalent to a 1-year rainfall storm recurrence interval. Additional rainstorm scenarios from 12 mm/hr. to 40 mm/hr. in 4 mm/hr. increments are provided in the USGS geodatabase for each wildfire. Rainfall recurrence intervals can also be estimated for a specific location from the NOAA Atlas 14: hdsc.new.noaa.gov.

- Modified flow regimes that impede or reduce the volitional migration of both adult and juvenile *O. mykiss* created by the construction and operation of the dams noted above, as well as water extractions that reduce the amount and extent of surface flow and the quality and availability of living space for rearing juvenile *O. mykiss* (*e.g*., Pajaro River and Salinas River, including the San Antonio River, Nacimiento River, and upper Salinas River).
- Sedimentation of channel substrate in the Pajaro River and its upper tributaries resulting from accelerated erosion rates attributed to surrounding land uses and turbid reservoir discharge.
- Degradation of estuarine habitat through runoff of impaired water quality through the introduction of fine sediments and pesticides (from urban and agricultural land uses), occasional artificial breaching of the sandbar, and reduction in the size and complexity of estuarine habitats from the intrusion of roads and railroad crossings, as well as urban and agricultural land-uses (*e.g*., Pajaro River, Salinas River).
- Periodic disruption of riverine and riparian habitats from flood control maintenance activities that include removal of riparian vegetation following or in anticipation of high winter flows in response to intense cyclonic storms (*e.g*., lower Pajaro River, Salinas River).
- The expansion of cannabis cultivation operations and related land-use and water supply developments that impact steelhead spawning and rearing habitat, particularly through the withdrawal of water for irrigation of cannabis crops.
- Drought and wildfire, followed by intense rainfall events generating elevated levels of sedimentation in core recovery watersheds, are pervasive threats throughout the Interior Coast Range BPG. See Figures 10 and 12.

The Interior Coast Range BPG has been subjected to repeated wildfires during the extended 5+ year drought extending from 2014 through the present. Continued threat of prolonged drought, and the related frequency, timing, intensity and magnitude of wildfires in response to climate changes present additional challenges to the existing remnant anadromous and related resident *O. mykiss* populations. NMFS' TRT concluded, "the three most prominent natural disturbances that appear to pose a risk to entire populations are wildfires, droughts, and debris flows" (Boughton *et al*. 2007); *see* Staley *et al*. (2020), Goss *et al*. (2020). Figure 12 depicts the extent of the 2020 River Fire, and the debris flow potential from a design storm within the watersheds contained within the perimeter of the River Fire, with the highest debris flow potential in the upper reaches of the watershed with steep slopes dominated by mixed coniferous and oak woodland vegetation.

Drying conditions and the consequent reduction in river flows, and in some cases, complete elimination of base flows has resulted in periodic rescue of rearing *O. myk*iss in the Uvas Creek and Corralitos Creek (tributaries to the Pajaro River), and in some cases mortalities (complicated by permitting issues, and COVID-19 related issues which prevented crews from engaging in rescue and relocation efforts); similar conditions have likely affected rearing conditions in the lower reaches of Arroyo Seco, and other southern tributaries to the Salinas River (Casagrande 2019; J. Casagrande, personal communication).

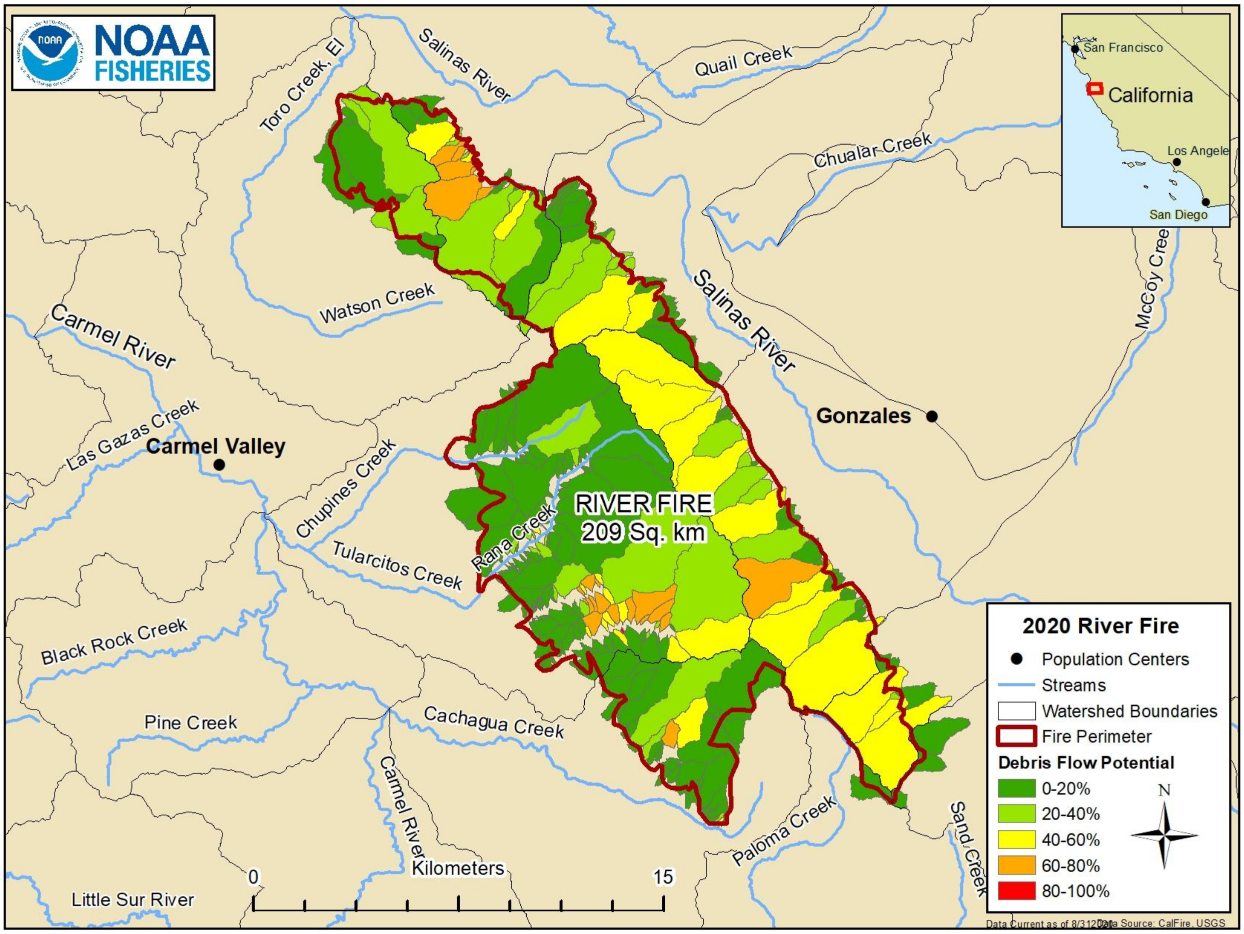

Figure 12. River Fire and Debris Flow Potential within the Interior Coast Range BPG. Other major fires within this BPG since 2016 include Soberanes Fire (2016), Dolan Fire (2020). Note: The map identifies where debris flows maybe initiated, but does not depict the eventual course of debris flow material. Source: U.S. Geological Survey, Landslide Hazards Program.

For further details on the methodology used by the USGS to determine debris flow potential, *see*: https://www.usgs.gov/programs/landslide-hazards/science/scientific-background

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

The specific habitat areas of concern for steelhead in the Interior Coast Range BPG remain essentially the same, but in some cases, the characteristics and conditions have been exacerbated by the increase in wildfire activity resulting from a combination of factors, including the prolonged drought and intensification of land-uses at the urban/wildland interface. The COVID-19 pandemic and related economic dislocations have also increased impacts to riparian areas and degradation of water quality through increased recreational use of open space areas and increased homeless use of riparian corridors (H. Garcia, personal communication).

The primary population-specific geographic areas of habitat concern for the Interior Coast Range BPG are:

- *San Antonio River, Nacimiento River, and Upper Salinas River*: Impediments to fish passage from road crossings, flood control structures, dams and diversions that restrict access to high quality spawning, rearing habitat and drought refugia habitat. These include San Antonio Dam on the San Antonio River (a tributary to the Salinas River), Nacimiento Dam on the Nacimiento River (a tributary to the Salinas River), and the Santa Margarita Dam (on the upper Salinas River).
- *Pajaro River, Salinas River*: Exotic aquatic species (*e.g*., striped bass) that compete with native *O. mykiss*, which can prey upon and transmit disease to native species.
- *Pajaro River*. On-going flood control practices and disturbance to channel morphology and riparian habitat affection steelhead migration. See Boughton and Pike (2012), Cluer and Thorne (2013), Klijn (2015).
- *Pajaro River/Uvas Creek, Salinas River*: Poaching/illegal angling out of season and with non-permitted gear further threatens the depleted populations in these watersheds.
- *Pajaro River/Uvas Creek, Salinas River*: The COVID-19 pandemic and related economic dislocations that have also increased impacts to riparian areas and degradation of water quality through increased recreational use of open space areas and increased homeless use of riparian corridors (H. Garcia, personal communication).
- *Salinas and Pajaro River* Loss or degradation of substantial amount of the original estuarine habitat from the degradation of water quality resulting from urban and agricultural runoff (including fine sediments and pesticides) that further affects the ability of anadromous *O. mykiss* to utilize these systems for rearing, acclimation, and ingress and egress to and from the ocean.
- *Salinas River, Pajaro River*: Continued threat of prolonged drought, and the related frequency and magnitude of wildfires in response to climate change present additional challenges to the existing remnant anadromous *O. mykiss* populations.
- Continued threat of prolonged drought, and the related frequency and magnitude of wildfires in response to climate changes that present additional challenges to all the existing remnant anadromous *O. mykiss* populations within the Interior Coast Range BPG; *see*, for example, Figures 10 and 12.
- *Salinas River/Arroyo Seco*: Impediments to fish passage from the mainstem of the Salinas River into the Arroyo Seco, resulting from groundwater pumping, surface diversions and road crossings, which restricts access to high quality spawning, rearing, and drought refugia habitat. Figure 13 depicts the deep pool steelhead spawning, rearing and refugia habitat within Arroyo Seco.

Figure 13. Arroyo Seco. June 24, 2005. The Arroyo Seco tributary is part of the Core 1 Salinas River watershed that provides steelhead spawning, rearing, and refugia habitat within the Salinas River watershed. Access to this habitat is constrained by groundwater pumping and the operation of three dams on tributaries within the Salinas River watershed (San Antonio Dam, Nacimiento Dam, and Santa Margarita Dam) that limit flows. Photo: Mark H. Capelli, National Marine Fisheries Service.

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

Since adoption of NMFS' South-Central California Coast Steelhead Recovery Plan in 2013, and NMFS' 2016 5-year review, the following key measures and restoration actions have addressed habitat concerns in the Interior Coast Range BPG:

- *Salinas River*: Initiation of Salinas River Invasive Non-Native Plan Control and Restoration Program (NMFS 2013a: Recovery Actions Sal-SCCCS-9.1 – 9.3)
- *Salinas River*: Initiation of Salinas River HCP process to address a range of fish passage and habitat restoration issues (NMFS 2013a: Recovery Actions Sal-SCCC-1.1 – 1.3; Sal-SCCCS-3.13.2; Sal-SCCCS-4.1 – 4.3: Sal-SCCCS-6.1 – 6.2).

- *Arroyo Seco*: Development and installation of a fish screen for the Clark County Water Company Diversion on Arroyo Seco (tributary to the Salinas River) (NMFS 2013a: Recovery Actions 4.1 – 4.3). See Figure 13.
- *Interior Coast Range BPG*: Completion of additional research on the *O. mykiss* complex, after 4 to 5 generations, which provides a temporal monitoring database that establishes a long-term time series of structure and abundance for populations of the Interior Coast Range BPG (NMFS 2013a: 8.1 DPS-Wide Recovery Actions).

These measures and restoration actions are responsive to recommendations for the recovery actions identified in NMFS' 2016 5-year review and 2013 South-Central California Steelhead Recovery Plan (NMFS 2013a).

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

NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) and NMFS' 2016 5-year review identified inadequate regulatory mechanisms as contributing substantially to the decline of the South-Central California Coast Steelhead DPS. Although many regulatory mechanisms and conservation efforts were in place at the time this DPS was listed as threatened, NMFS concluded that they were insufficient to provide for the attainment of properly functioning habitat conditions for the recovery of the species.

Various federal, state, county and city regulatory mechanisms have the potential to minimize or avoid habitat degradation caused by human land uses and water development. The development of NMFS' 2013 South-Central California Coast Steelhead Recovery Plan (2013a) and designation of critical habitat provides significant guidance for restoration of habitats of the core recovery populations within the Interior Coast Range BPG. Additionally, the application of the ESA's Section 7 and Section 10 regulatory processes has substantially enhanced the regulatory oversight of projects affecting listed *O. mykiss* and designated critical habitat within the Interior Coast Range BPG. Significantly, the passage of the Sustainable Groundwater Management Act (SGMA) has provided a new regulatory mechanism for managing groundwater resources that have been identified as a major issue in the restoration of core recovery populations within in the Interior Coast Range BPG.

Implementation of NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) is an on-going process and the effectiveness of related local, state, and federal regulatory mechanisms and related planning programs has not been comprehensively evaluated, though the most relevant features of these regulatory mechanisms and programs have been reviewed. See the discussion in "Listing Factor D: Inadequacy of Regulatory Mechanisms."

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

The following recovery actions are recommended over the next 5 years to increase population viability of steelhead populations in the Interior Coast Range BPG. The actions address the principal emergent or ongoing habitat concerns since NMFS' 2016 5-year review. For a list of potential collaborators for the individual recovery actions, *see* "South-Central California

Steelhead DPS Recovery Action Tables, Interior Coast Range BPG (Tables 9-4 – 9-6)" in NMFS (2013a).

- Implement College Lake Integrated Resources Management Plan Project to improve rearing habitat and volitional steelhead passage through the lake, Casserly Creek and lower Salsipuedes Creek (tributaries to Pajaro River) (NMFS 2013a: Recovery Actions Paj-SCCCS-3.1 - 3.2; Paj-SCCCS-4.1 – 4.3; Paj-SCCCS-5.1).
- Reduce dry season flow diversions from Corralitos Creek and tributaries to Uvas Creek (tributaries to Pajaro River) and expand winter-forbearance storage projects (NMFS 2013a: Recovery Actions Paj-SCCCS-3.1 – 3.2).
- Implement Llagas Creek Flood Control Project (tributaries to Pajaro River) (NMFS 2013a: Recovery Actions Paj-SCCCS-3.1 – 3.2).
- Implement removal of Pickell Dam on Little Arthur Creek and implement Bolsa Road Fish Passage Improvement project on lower Uvas Creek (tributaries to Pajaro River) (NMFS 2013a: Recovery Actions Paj-SCCCS-UC-4.1 – 4.3)
- Improve volitional fish passage at elevated road crossings in Arroyo Seco (tributary to the Salinas River); specifically, the Sycamore Flats, Miller, and Arroyo Seco Resort road crossings (NMFS 2013a: Recovery Actions AS-SCCCS-3.1 – 3.2).
- Improve volitional fish passage at the Salinas River Lagoon slide gate to the Old Salinas River channel and at the Potrero tide gates, and improve riparian habitat conditions along the Old Salinas River channel from the lagoon to Elkhorn Slough. (NMFS 2013a: Recovery Actions Sal-SCCCS-1.2; Sal-SCCCS-3.1 – 3.2).
- Complete studies to facilitate habitat conservation planning for the Salinas River and it two major tributaries (Nacimiento River and San Antonio River), including the upper watershed tributaries (*e.g*., spawning, rearing, and migratory habitat assessments upstream of major dams, fish passage scenarios, river flow modeling, *etc.*) (NMFS 2013a: Recovery Actions Sal-SCCCS-4.1– 4.3; Sant-SCCCS-4.1 – 4.3; Nac- SCCCS-4.1 – 4.3).
- Begin implementing the Updated Strategy for Steelhead Viability Monitoring in the Southern Coastal Area (Boughton *et al*. 2020) (NMFS 2013a: Recovery Actions 8.1 DPS-Wide Recovery Actions).

Carmel River BPG

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

- Impediments to fish passage from road crossings, flood control structures, dams and diversions that restrict access to high quality spawning, rearing habitat and drought refugia habitat within the Carmel River watershed.
- Exotic aquatic species (*e.g*., striped bass in the Carmel River and lagoon) that can compete with native *O. mykiss*, as well as prey upon and transmit disease to native species.
- The COVID-19 pandemic and related economic dislocations that have also increased impacts to riparian areas and degradation of water quality through increased recreational use of open space areas and increased homeless use of riparian corridors.

- The expansion of cannabis cultivation operations and related land-use and water supply developments that impact steelhead spawning and rearing habitat, particularly through the withdrawal of water for irrigation of cannabis crops, and from the degradation of water quality resulting from runoff (including fine sediments and pesticides)
- Drought and wildfire, followed by intense rainfall events generating elevated levels of sedimentation in core recovery watersheds, are pervasive threats throughout the Carmel River Basin BPG. See Figures 12 and 14.

The Carmel River Basin BPG has been subjected to repeated wildfires during the extended 5+ year drought extending from 2014 through the present. Continued threat of prolonged drought, and the related frequency timing, intensity and magnitude of wildfires in response to climate changes present additional challenges to the existing remnant anadromous and related resident *O. mykiss* populations. NMFS' TRT concluded, "the three most prominent natural disturbances that appear to pose a risk to entire populations are wildfires, droughts, and debris flows" (Boughton *et al*. 2007); *see* also, Staley *et al*. (2020). Figure 14 depicts the extent of the 2020 Carmel Fire, and the debris flow potential from a design storm within the watersheds contained within the perimeter of the Carmel Fire, with the highest debris flow potential in the upper reaches of the watershed with steep slopes dominated by mixed coniferous and oak woodland vegetation.

Drying conditions and the consequent reduction river flows, and in some cases, complete elimination of base flows has resulted in periodic rescue of rearing *O. myk*iss in the lower reaches of the Carmel River below Los Padres Dam, and in some cases mortalities (complicated by permitting issues, and COVID-19 related issues which prevented crews from engaging in rescue and relocation efforts (J. Casagrande, personal communication).

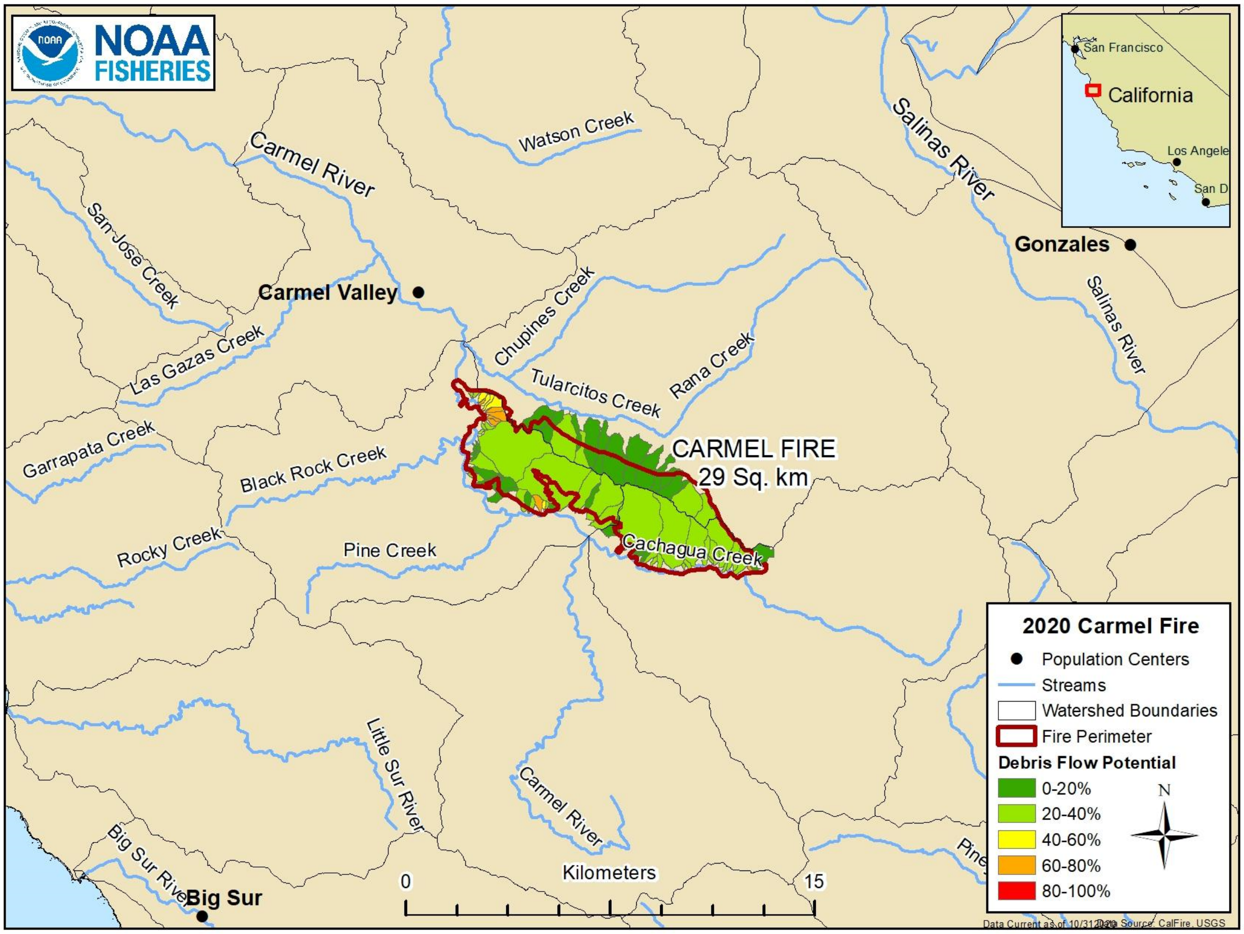

Figure 14. Carmel Fire and Debris Flow Potential within the Carmel River Basin BPG. Other major fires within this BPG since 2016 include: River Fire (2020). Note: The map identifies where debris flows may be initiated, but does not depict the eventual course of debris flow material. Source: U.S. Geological Survey, Landslide Hazards Program.

For further details on the methodology used by the USGS to determine debris flow potential, *see*: https://www.usgs.gov/programs/landslide-hazards/science/scientific-background

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

The specific habitat areas of concern for steelhead in the Carmel River BPG remain essentially the same, but in some cases have been ameliorated (*e.g.*, removal of San Clemente Dam) and in other cases exacerbated by the increase in wildfire activity resulting from a combination of factors, including the prolonged drought and intensification of land-uses at the urban/wildland interface. The COVID-19 pandemic and related economic dislocations have also increased impacts to riparian areas degraded water quality through increased recreational use of open space areas and increased homeless use of riparian corridors. The primary habitat issues of concern for the Carmel River Basin BPG are:

- *Carmel River*: Impediments to fish passage from road crossings, flood control structures, dams and diversions that restrict access to spawning and rearing habitat and drought refugia habitat in the mainstem and tributaries of the Carmel River.
- *Carmel River*: Groundwater extractions that depress the groundwater levels that affect surface flows, particularly base flows that are critical to support rearing juvenile *O. mykiss* in the Carmel watershed, particularly in the lower mainstem; *see*, Normandeau Associates (2019).
- *Carmel River*: Exotic aquatic species (*e.g*., striped bass) that can compete with native *O. mykiss*, as well as prey upon and transmit disease to native species.
- *Carmel River*: Degradation of water quality from urban and agricultural runoff that affect base flows that are critical to support rearing juvenile *O. mykiss* in the Carmel watershed, particularly in the lower and middle mainstem.
- *Carmel River Estuary*: Loss of estuarine habitat through encroachment of residential development, and degradation of water quality from urban and agricultural runoff (including fine sediments and pesticides), as well as periodic unauthorized breaching of the Carmel River Estuary sandbar by private parties, has affected the ability of anadromous *O. mykiss* to utilize the lagoon for rearing; *see*, NMFS (2019b), Largier *et al.* (2019).
- *Carmel River*: The COVID-19 pandemic and related economic dislocations have increased impacts to riparian areas and degraded water quality through increased recreational use of open space areas and increased homeless use of riparian corridors.
- *Carmel River*: Continued threat of prolonged drought, and the related frequency and magnitude of wildfires in response to climate changes present additional challenges to the existing remnant anadromous *O. mykiss* populations. See Figures 12 and 14.
- *San Jose Creek*: Degradation of estuarine habitat through runoff of impaired water quality from urban and agricultural land uses (including fine sediments and pesticides), artificial breaching of the sandbar, and reduction in the size and complexity of estuarine habitat resulting from encroachment of roadways.
- Continued threat of prolonged drought, and the related frequency and magnitude of wildfires in response to climate changes that present additional challenges to the existing remnant anadromous *O. mykiss* populations within the Carmel River Basin BPG. Figure 15 depicts the Carmel River below the San Clemente Dam site that contains high quality steelhead spawning, rearing, and refugia habitat, following removal of San Clemente Dam.

Figure 15. Carmel River below the San Clemente Dam site following removal of San Clemente Dam. May 10, 2017. The Carmel River is a Core 1 watershed that provides steelhead spawning, rearing, and refugia habitat within its upper headwaters and tributaries. Access to this habitat is constrained by groundwater extractions in the lower reaches and the Los Padres Dam in its upper reaches. Photo: Mark H. Capelli, National Marine Fisheries Service.

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

Since adoption of the Recovery Plan in 2013, and NMFS' 2016 5-year review, the following key measures and restoration actions have addressed habitat concerns in the Carmel River BPG:

- Removal of San Clemente Dam and Old Carmel River Dam on the lower mainstem of the Carmel River (NMFS 2013a: Recovery Action Car-SCCCS-4.3). See Figure 15.
- Retirement of approximately 400 acre-feet of summer irrigation from the Rancho Canada Golf Course on the lower Carmel River (NMFS 2013a: Recovery Actions Car-SCCCS-4.1 – 4.2).

- Removal of steelhead passage barriers in portions of four tributaries to the Carmel River (San Clemente Creek, Cachagua Creek, Potrero Creek, Mainstem Creek) (NMFS 2013a: Recovery Actions Car-SCCCS-3.1 – 3.2).
- Initiation of an alternative water supply (Pure Water Monterey) for the Carmel River water service area, installation of large woody debris in to the Carmel River Estuary, and spawning gravel supplementation at the base of Los Padres Dam (NMFS 2013a: Recovery Actions Car-SCCCS-S-4.1 – 4.2; Car-SCCCS-S-12.1; Car-SCCCS-7.1)

These measures and restoration actions are responsive to recommendations for the recovery actions identified in NMFS' 2016 5-year review and 2013 South-Central California Coast Steelhead Recovery Plan (NMFS 2013a).

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

NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) and NMFS' 2016 5-year review identified inadequate regulatory mechanisms as contributing substantially to the decline of the South-Central California Coast Steelhead DPS. Although many regulatory mechanisms and conservation efforts were in place at the time this DPS was listed as threatened, NMFS concluded that they were insufficient to provide for the attainment of properly functioning habitat conditions for the recovery of the species.

Various federal, state, county and city regulatory mechanisms have the potential to minimize or avoid habitat degradation caused by human land uses and water development. The development of NMFS' 2013 South-Central California Coast Steelhead Recovery Plan (2013a) and designation of critical habitat provides significant guidance for restoration of habitats of the core recovery populations within the Carmel River Basin BPG. Additionally, the application of the ESA's Section 7 and Section10 regulatory processes has substantially enhanced the regulatory oversight of projects affecting listed *O. mykiss* and designated critical habitat within the Carmel River Basin BPG. Significantly, the passage of the SGMA has provided a new regulatory mechanism for managing groundwater resources that have been identified as a major issue in the restoration of core recovery populations within in the Carmel River Basin BPG. Also, the State Water Resources Control Board has adopted an order that establishes a diversion limit with milestones and penalties for diversion from the Carmel River. However, this order has not been fully implemented, and the adequacy of its provisions to protect the steelhead population of the Carmel River have not been evaluated.

Implementation of NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) is an on-going process and the effectiveness of related local, state, and federal regulatory mechanisms and related planning programs has not been comprehensively evaluated, though the most relevant features of these regulatory mechanisms and programs have been reviewed. See the discussion in "Listing Factor D: Inadequacy of Regulatory Mechanisms."

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

The following recovery actions are recommended over the next 5 years to increase population viability of the south-central California steelhead population in the Carmel River Basin BPG.

The actions address the principal emergent or ongoing habitat concerns since NMFS' 2016 5-year review. For a list of potential collaborators for the individual recovery actions, *see* "South-Central California Steelhead DPS Recovery Action Table, Carmel River Basin BPG (Table 10-4)" in NMFS (2013a).

- Finalize evaluations of Los Padres Dam (including removal) and advance a preferred alternative to enable the preparation of an Environmental Impact Statement/Environmental Impact Report; in the interim implement actions to improve access to the fish ladder and trap at Los Padres Dam, and to improve emigration of juvenile and kelts downstream from Los Padres Dam (NMFS 2013a: Recovery Actions Car-SCCCS- 4.1 – 4.3).
- Implement the State Water Resources Control Board's Cease and Desist Order for surface-water diversions from the Carmel River (NMFS 2013a: Recovery Actions Car-SCCCS-6.1 – 6.2).
- Remediate fish passage barriers identified in the Monterey Peninsula Water Management District Report "Assessment of Steelhead Passage Barriers in Portions of Four Tributaries to the Carmel River" (2014) (NMFS 2013a: Recovery Actions Car-SCCCS-3.1 – 3.2).
- Implement the "Carmel River Floodplain Restoration and Environment Project" and floodplain habitat restoration at the former Rancho Canada Golf Course (NMFS 2013a: Recovery Actions Car-SCCCS-7.1 – 7.3).
- Finalize design of the "Scenic Road Protection Project" at the Carmel River Estuary (NMFS 2013a: Recovery Actions Car-SCCCS-11.1 – 11.3; Car-SCCCS-12.1; Car-SCCCS 13.2).
- Begin implementing the Updated Strategy for Steelhead Viability Monitoring in the Southern Coastal Area (Boughton *et al*. 2020) (NMFS 2013a: Recovery Actions 8.1 DPS-Wide Recovery Actions).

Big Sur Coast BPG

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

- Modified flow regimes that impede or reduce the volitional migration of adult and juvenile *O. mykiss* created by the seasonal surface diversions, and groundwater wells that drawdown groundwater levels and reduce or eliminate base flows and degrade water quality affecting the quality and extent of living space for rearing juvenile *O. mykiss* (*e.g*., San Jose Creek, Big Sur River).
- Sedimentation of channel substrate resulting from erosion on surrounding land uses, degradation of water quality from point and non-point sources, degradation or loss of spawning and rearing habitat (*e.g.*, San Jose Creek, Little Sur River, Big Sur River).
- Management of large woody material within the developed portions of watersheds (*e.g*., Big Sur River).
- Impediments to fish passage, including road crossings, seasonal surface diversions (*e.g*., San Jose Creek, Big Sur River).

- The expansion of cannabis cultivation operations and related land-use and water supply developments that impact steelhead spawning and rearing habitat, particularly through the withdrawal of water for irrigation of cannabis crops.
- Drought and wildfire, followed by intense rainfall events generating elevated levels of sedimentation in core recovery watersheds, are pervasive threats throughout the Big Sur Coast BPG.

The Big Sur Coast BPG has been subjected to repeated wildfires during the extended 5+ year drought extending from 2014 through the present. Continued threat of prolonged drought, and the related frequency, timing, intensity and magnitude of wildfires in response to climate changes present additional challenges to the existing remnant anadromous and related resident *O. mykiss* populations. NMFS' TRT concluded, "the three most prominent natural disturbances that appear to pose a risk to entire populations are wildfires, droughts, and debris flows" (Boughton *et al*. 2007); *see* also, Staley *et al*. (2020). Figure 16 depicts the extent of the 2016 Sobaranes Fire and the debris flow potential from a design storm within the watersheds contained within the perimeter of the Sobaranes Fire, with the highest debris flow potential in the upper reaches of the watershed with steep slopes dominated by mixed coniferous and oak woodland vegetation.

Big Creek watershed has been significantly impacted by the Dolan Fire, with the majority of the watershed burned. There were no reported cases of *O. mykiss* mortalities (though access has been complicated by COVID-19 related issues); similar conditions have likely affected rearing conditions for juvenile steelhead in the reaches of the Big Sur Coast affected by recent fires (T. Williams, personal communication). Figure 17 depicts the extent of the 2020 Dolon Fire, and the debris flow potential from a design storm within the watersheds contained within the perimeter of the Dolon Fire, with the highest debris flow potential in the upper reaches of the watershed with steep slopes dominated by mixed conifer, grassland, and oak woodland vegetation.

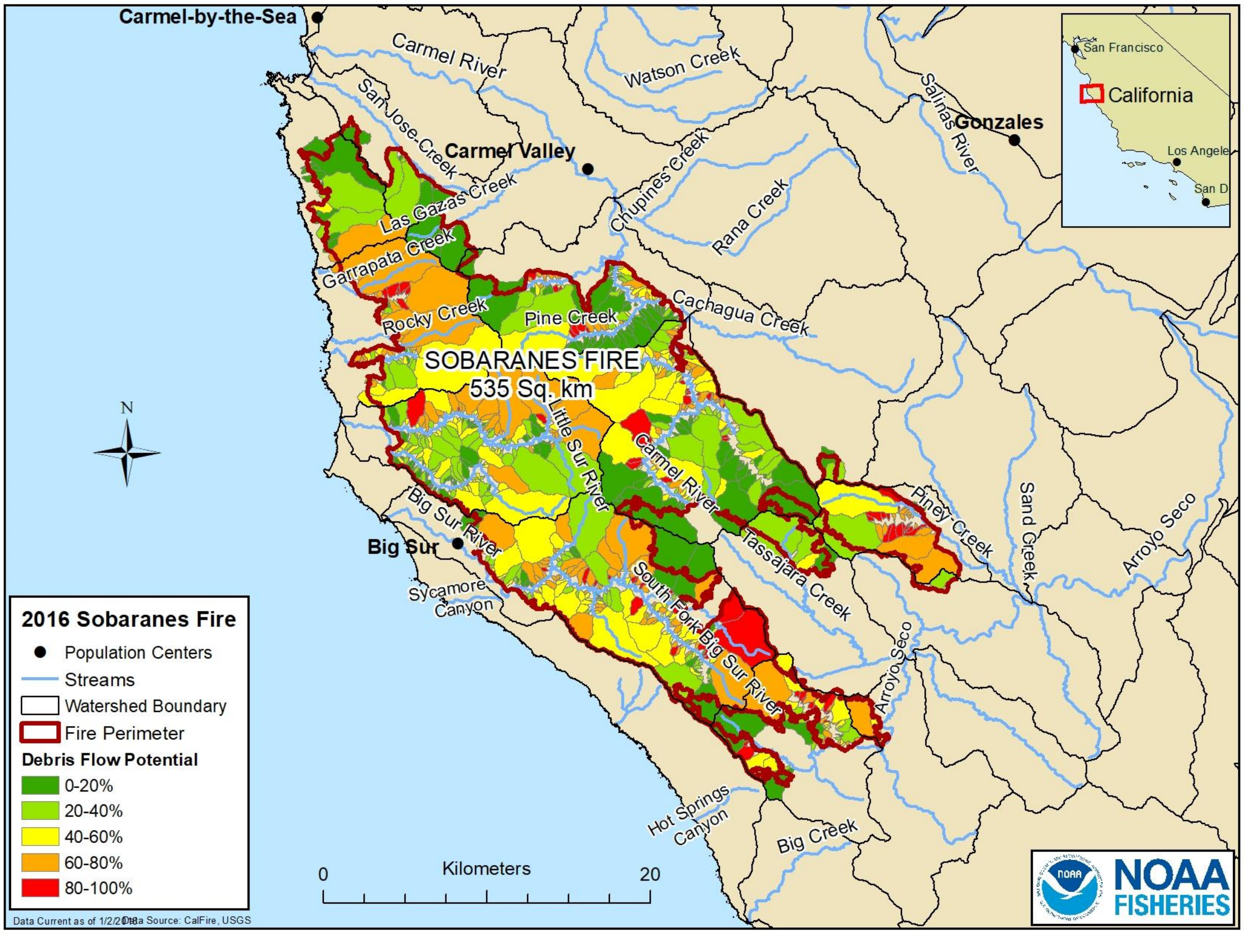

Figure 16. Sobaranes Fire and Debris Flow Potential within the Big Sur Coast BPG. Other major fires within this BPG since 2016 include: Dolan Fire (2020). Note: The map identifies where debris flows may be *initiated,* but does not depict the eventual course of debris flow material. Source: U.S. Geological Survey, Landslide Hazards Program.

For further details on the methodology used by the USGS to determine debris flow potential, *see*: https://www.usgs.gov/programs/landslide-hazards/science/scientific-background

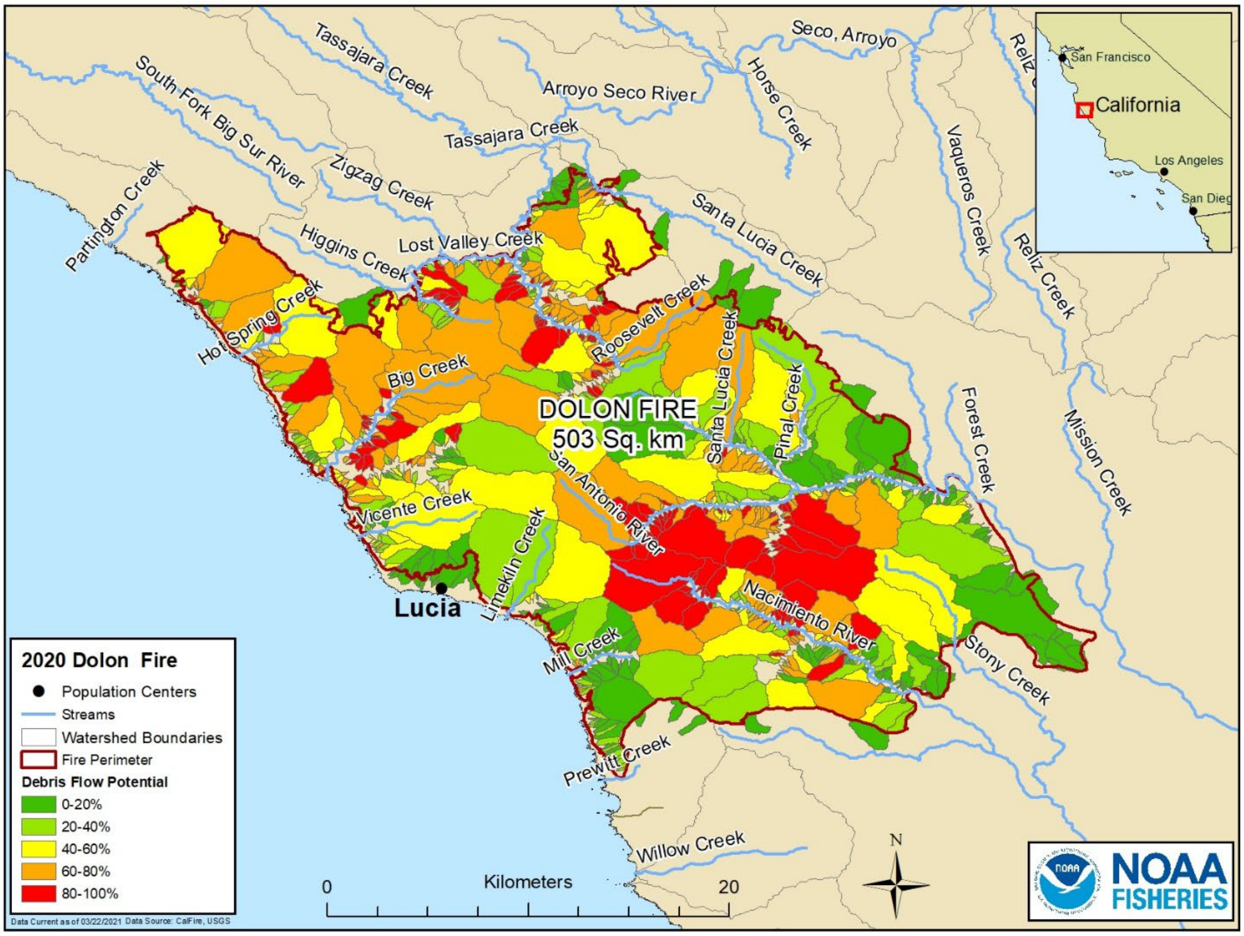

Figure 17. Dolan Fire and Debris Flow Potential within the Big Sur Coast BPG. Other major fires within this BPG since 2016 include: Sobaranes Fire (2016). Note: The map identifies where debris flows may be *initiated,* but does not depict the eventual course of debris flow material. Source: U.S. Geological Survey, Landslide Hazards Program.

For further details on the methodology used by the USGS to determine debris flow potential, *see*: https://www.usgs.gov/programs/landslide-hazards/science/scientific-background

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

There is no additional information available since NMFS' 2016 5-year review that identifies specific new habitat areas of concern for steelhead in the Big Sur Coast BPG. The primary habitat issues of concern for the Big Sur Coast BPG include:

- *San Jose Creek*: Impediments to fish passage from road crossings and diversions that restrict access to high quality spawning, rearing habitat and drought refugia habitat in the mainstem and tributaries of the San Jose Creek.
- *San Jose Creek Estuary*: Degradation of estuarine habitat through runoff of impaired water quality from urban and agricultural land uses (including fine sediments and pesticides),

artificial breaching of the San Jose Creek Estuary sandbar, and reduction in the size and complexity of estuarine habitat resulting from encroachment of roadways, has further affected the ability of anadromous *O. mykiss* to utilize the watershed for rearing, acclimation, and ingress and egress.

- *Little Sur River*: Impediments to fish passage from seasonal road crossings in the upper reaches that restrict access to high quality spawning, rearing habitat and drought refugia habitat in the mainstem and tributaries of the Little Sur River.
- *Big Sur River*: Groundwater extractions in the lower reaches that depress the groundwater levels that affect surface flows, particularly base flows that are critical to support rearing juvenile *O. mykiss* in the Big Sur River watershed, especially in the lower mainstem and estuary. See Allen and Riley (2012), Holmes *et al.* (2014, 2016), CDFW (2016b). Figure 18 depicts the steelhead spawning, rearing, and refugia habitat Big Sur River below Highway 1 that is impacted by recreational development and groundwater extractions in its lower reaches.
- *Big Sur River*: Large woody material abundant in the Big Sur River in conjunction with periodic heavy sediment or debris flows has the potential to impede fish passage in a narrow gorge in the lower river, constricting access to a majority of the spawning and rearing habitat within the Big Sur River watershed.
- *Big Sur Coast BPG*: Continued threat of prolonged drought, and the related frequency and magnitude of wildfires in response to climate changes that present additional challenges to the existing remnant anadromous *O. mykiss* populations within the Big Sur Coast BPG.

Figure 18. Big Sur River below Highway 1. March 12, 2007. The Big Sur River is a Core 1 watershed that provides steelhead spawning, rearing, and refugia habitat in it its headwaters and tributaries but is impacted by recreational development and groundwater extractions in its lower reaches. Photo: Mark H. Capelli, National Marine Fisheries Service.

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

Since adoption of NMFS' South-Central California Coast Steelhead Recovery Plan in 2013 (2013a) and NMFS' 2016 5-year review, the following key measures and restoration actions have addressed habitat concerns in the Big Sur Coast BPG:

- Implementation of the California Coastal Monitoring Plan on the Big Sur River, including adult monitoring with DIDSON (Dual-Frequency Identification Sonar), spawning surveys, juvenile snorkel surveys, and sample frame development; *see* Pipal, *et al.* (2010a, 2010b, 2012) (NMFS 2013a: Recovery Actions 8.1 DPS-Wide Recovery Actions).
- Development of instream flow recommendations for the Big Sur River (NMFS 2013a: Recovery Actions BS-SCCCS-6.1– 6.2).

These measures and restoration actions are responsive to recommendations for the recovery actions identified in NMFS' 2016 5-year review and 2013 South-Central California Coast Steelhead Recovery Plan (NMFS 2013a).

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

NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) and NMFS' 2016 5-year review identified inadequate regulatory mechanisms as contributing substantially to the decline of the South-Central California Coast Steelhead DPS. Although many regulatory mechanisms and conservation efforts were in place at the time this DPS was listed as threatened, NMFS concluded that they were insufficient to provide for the attainment of properly functioning habitat conditions for the recovery of the species.

Various federal, state, county and city regulatory mechanisms have the potential to minimize or avoid habitat degradation caused by human land uses and water development. The development of NMFS' 2013 South-Central California Coast Steelhead Recovery Plan (2013a) and designation of critical habitat provides significant guidance for restoration of habitats of the core recovery populations within the Big Sur Coast BPG. Additionally, the application of the ESA's Section 7 and Section10 regulatory processes has substantially enhanced the regulatory oversight of projects affecting listed *O. mykiss* and designated critical habitat within the Big Sur Coast BPG. Significantly, the passage of the SGMA has provided a new regulatory mechanism for potentially managing groundwater resources that have been identified as a major issue in the restoration of core recovery populations within in the Big Sur Coast BPG.

Implementation of NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) is an on-going process and the effectiveness of related local, state, and federal regulatory mechanisms and related planning programs has not been comprehensively evaluated, though the most relevant features of these regulatory mechanisms and programs have been reviewed. See the discussion in "Listing Factor D: Inadequacy of Regulatory Mechanisms."

5) Recommended Future Actions over the Next 5 Years toward Achieving Population Viability

The following recovery actions are recommended over the next 5 years to increase population viability of south-central California steelhead populations in the Big Sur Coast BPG. The actions address the principal emergent or ongoing habitat concerns since NMFS' 2016 5-year review. For a list of potential collaborators for the individual recovery actions, *see* "South-Central California Steelhead DPS Recovery Action Tables, Big Sur Coast BPG (Tables 11-4 – 11-10)" in NMFS (2013a).

- Develop and implement a groundwater management plan to reduce impacts to rearing juvenile *O. mykiss* in San Jose Creek (NMFS 2013a: Recovery Actions SJC-SCCCS-6.1 – 6.2).
- Complete an assessment of sandbar breaching patterns of the San Jose Creek Estuary and develop and implement management options to reduce impacts on rearing juvenile steelhead (NMFS 2013a: Recovery Action SJC-SCCCS-12.1).

- Develop and implement a plan to remove or modify fish passage barriers in San Jose Creek to allow natural rates of steelhead migration to upstream spawning and rearing habitats (NMFS 2013a: Recovery Actions SJC-SCCCS-3.1 – 3.2).
- Implement instream flow recommendations for the Big Sur River (NMFS 2013: Recovery Actions BS-SCCCS-6.1 – 6.2).
- Develop and implement a large woody material management plan for Pfeiffer Big Sur and Andrew Molera State Parks (NMFS 2013a: Recovery Actions BS-SCCCS-10.1 – 10.2).
- Begin implementing the Updated Strategy for Steelhead Viability Monitoring in the Southern Coastal Area (Boughton *et al*. 2022b) (NMFS 2013a: Recovery Actions 8.1 DPS-Wide Recovery Actions).

San Luis Obispo Terrace BPG

1) Population-Specific Key Emergent or Ongoing Habitat Concerns since the 2016 Review

- Modified flow regimes that impede or reduce the volitional migration of adult and juvenile *O. mykiss* created by the seasonal surface diversions, and groundwater wells that drawdown groundwater levels and reduce the amount and extent of surface flow and the quality and availability of living space, particularly for rearing juvenile *O. mykiss* (*e.g*., San Simeon Creek, Santa Rosa Creek, Pismo Creek, San Luis Obispo Creek, Arroyo Grande Creek).
- Sedimentation of channel substrate resulting from erosion on surrounding land uses, degradation of water quality from point and non-point sources (including fine sediments and pesticides), degradation or loss of spawning and rearing habitat (*e.g.*, Santa Rosa Creek, San Luis Obispo Creek, Arroyo Grande Creek).
- Impediments to fish passage, including road crossings, seasonal surface-water diversions (*e.g*., San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek).
- Degradation of estuarine habitat through runoff of impaired water quality from both urban and agricultural land uses (including fine sediments and pesticides), artificial breaching of the sandbar, and reduction in the size and complexity of estuarine habitats resulting from the intrusion of roads and railroad crossings, and urban and agricultural land-uses (*e.g*., Santa Rosa Creek, Morro Bay Complex [Chorro and Los Osos creeks], San Luis Obispo Creek, Pismo Creek, Arroyo Grande Creek). See California Conservation Corps (2012a, 2012b, 2013a, 2013b), San Luis County Office of Education (2020).
- The expansion of cannabis cultivation operations and related land-use and water supply developments that impact steelhead spawning and rearing habitat, particularly through the withdrawal of water for irrigation of cannabis crops, and from the degradation of water quality resulting from runoff (including fine sediments and pesticides).
- Drought and wildfire, followed by intense rainfall events generating elevated levels of sedimentation in core recovery watersheds, are pervasive threats throughout the San Luis Obispo Terrace BPG. For example, CDFW staff documented 11 adult steelhead and several thousand young-of-the-year steelhead dying as a result of drought conditions in San Simeon Creek (D. Baldwin, personal communication). See Figure 10.

Continued threat of prolonged drought and climate changes present additional challenges to the existing remnant anadromous *O. mykiss* population within the San Luis Obispo Terrace BPG. NMFS' TRT concluded, "The three most prominent natural disturbances that appear to pose a risk to entire populations are wildfires, droughts, and debris flows" (Boughton *et al*. 2007); *see* also, Staley *et al*. (2020).

Drying conditions and the consequent reduction river flows, and in some cases, complete elimination of base flows has resulted in mortalities (complicated by COVID-19 related issues which prevented crews from engaging in rescue and relocation efforts); adult steelhead entering San Luis Obispo Creek in the winter of 2021 were stranded as a result of dropping flows preventing them from moving between pools, and some ultimately died (F. Otte, personal communication). San Carpoforo Creek and Arroyo de la Cruz Creek, situated in the northernmost portion of the San Luis BPG are two of least disturbed, and best protected steelhead watersheds within the South-Central California Coast Steelhead DPS. Figure 19 depicts Arroyo de la Cruz Creek Estuary and that provides important rearing and refugia habitat.

2) Population-Specific Geographic Areas of Habitat Concern since the 2016 Review

There is no additional information available since NMFS' 2016 5-year review that identifies specific new habitat areas of concern for steelhead in the San Luis Obispo Terrace BPG. The primary habitat issues of concern for the San Luis Obispo Terrace BPG are:

- *San Luis Obispo Creek*: Impediments to fish passage from road crossings and surface-water diversion dams (including the Marre Dam) that restrict access to high quality spawning, rearing habitat and drought refugia habitat in the mainstem and tributaries of the San Luis Obispo Creek.
- *San Luis Obispo Creek Estuary*: Loss of estuarine habitat, particularly (including degradation of water quality from agricultural runoff (including fine sediments and pesticides) and artificially fragmenting the estuary with the Marre Dam). Artificial breaching of the San Luis Obispo Creek Estuary sandbar has further affected the ability of steelhead to utilize the watershed for rearing, acclimation, ingress and egress.
- *Pismo Creek and Arroyo Grande Creek Estuary*: Loss of estuarine habitat, particularly (including degradation of water quality from agricultural runoff(including fine sediments and pesticides) Artificial breaching of the Pismo Creek Estuary and Arroyo Grande Estuary sandbars have further affected the ability of steelhead to utilize the watershed for rearing, acclimation, ingress and egress.
- *Pismo Creek*: Impediments to fish passage in the upper reaches of the estuary that restrict access to high quality spawning, rearing habitat and drought refugia habitat in the mainstem and tributaries of the Pismo Creek.
- *Arroyo Grande Creek*: Impediments to fish passage, on-going flood control maintenance activities, and water withdrawals in the lower reaches and Lopez Dam that restrict access to high quality spawning, rearing habitat and drought refugia habitat in the mainstem and

tributaries of Arroyo Grande Creek. See Swanson Hydrologic and Geomorphology (2008), Rischbieter *et al*. (2015), NMFS (2017a).

- *San Luis Obispo Terrace BPG*: Groundwater extractions in the lower reaches that depress the groundwater levels that affect surface flows, particularly base flows that are critical to support rearing juvenile *O. mykiss* in the watershed, particularly in the lower mainstems and estuaries.
- *San Luis Obispo Terrace BPG*: The COVID-19 pandemic and related economic dislocations have increased impacts to riparian areas and degradation of water quality through increased recreational use of open space areas and increased homeless use of riparian corridors (D. Baldwin, personal communication).
- *San Luis Obispo Terrace BPG*: Continued threat of prolonged drought, and the related frequency and magnitude of wildfires in response to climate changes present additional challenges to the existing remnant anadromous *O. mykiss* populations.

Figure 19. Arroyo de la Cruz Creek, looking west toward the Arroyo de la Cruz Creek Estuary and Pacific Ocean. May 1, 2011. Arroyo de la Cruz Creek is a Core 2 population that provides steelhead spawning, rearing, and refugia habitat in its upper reaches and tributaries. It is one of only a few watersheds within the South-Central California Coast Steelhead DPS that has not been impacted by extensive development. Photo: Mark H. Capelli, National Marine Fisheries Service.

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

Since adoption of NMFS' South-Central California Coast Steelhead Recovery Plan in 2013 (NMFS 2013a), and NMFS' 2016 5-year review, following key measures and restoration actions have addressed habitat concerns in the San Luis Obispo Terrace BPG:

- Implemented bank stabilization and sediment reduction program on Santa Rosa Creek (NMFS 2013a: Recovery Action SR-SCCCS-5.1; SR-SCCCS-7.1 – 7.3).
- Replaced at-grade, culverted road crossing on Santa Rosa Creek with free-span bridge (NMFS 2013a: Recovery Action SR-SCCCS-3.1 – 3.2).
- Implemented restoration measures within the Morro Bay Complex *(e.g.*, side channel/floodplain and sediment reduction on Chorro Creek; removal of diversion dam and stream restoration on Pennington Creek; *see* Trout Unlimited 2019, 2020); control of non-native aquatic species in Chorro Creek watershed) (NMFS 2013a: Recovery Actions CC-SCCCS-5.1; CC-SCCCS-7.1 – 7.1; CC-SCCCS-4.1 – 4.3; CC-SCCCS-9.1 – 9.3).
- Initiated limited steelhead monitoring in San Luis Obispo Creek (NMFS 2013a: Recovery Actions 8.1 DPS-Wide Recovery Actions).
- Implemented flood control/bank stabilization and stream restoration program on lower Arroyo Grande Creek (NMFS 2013a: Recovery Actions AG-SCCCS-7.1 – 7.3).

These measures and restoration actions are responsive to recommendations for the recovery actions identified in NMFS' 2016 5-year review and 2013 South-Central California Coast Steelhead Recovery Plan (NMFS 2013a).

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

NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) and NMFS' 2016 5-year review identified inadequate regulatory mechanisms as contributing substantially to the decline of the South-Central California Coast Steelhead DPS. Although many regulatory mechanisms and conservation efforts were in place at the time this DPS was listed, NMFS concluded that they were insufficient to provide for the attainment of properly functioning habitat conditions for the recovery of the species.

Various federal, state, county and city regulatory mechanisms have the potential to minimize or avoid habitat degradation caused by human land uses and water development. The development of NMFS' 2013 South-Central California Coast Steelhead Recovery Plan (2013a) and designation of critical habitat provides significant guidance for restoration of habitats of the core recovery populations within the San Luis Obispo Terrace BPG. Additionally, the application of the ESA's Section7 and Section10 regulatory processes has substantially enhanced the regulatory oversight of projects affecting listed *O. mykiss* and designated critical habitat within the San Luis Obispo Terrace BPG. Significantly, the passage of the SGMA has provided a new regulatory mechanism for managing groundwater resources that have been identified as a major issue in the restoration of core recovery populations within in the San Luis Obispo Terrace BPG.

Implementation of NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) is an on-going process and the effectiveness of related local, state, and federal regulatory mechanisms and related planning programs has not been comprehensively evaluated, though the most relevant features of these regulatory mechanisms and programs have been reviewed. See the discussion in "Listing Factor D: Inadequacy of Regulatory Mechanisms."

5) Recommended Future Actions over the Next 5 Years toward Achieving Population Viability

The following recovery actions are recommended over the next 5 years to increase population viability of south-central California steelhead populations in the San Luis Obispo Terrace BPG. The actions address the principal emergent or ongoing habitat concerns since NMFS' 2016 5-year review. For a list of potential collaborators for the individual recovery actions, *see* "South-Central California Steelhead DPS Recovery Action Tables, San Luis Obispo Terrace BPG (Tables 12-4 – 12-13)" in NMFS (2013a).

- Inventory, prioritize, and initiate remediation of fish passage barriers to upper watershed spawning/rearing habitats *(e.g*., Morro Bay Complex, San Luis Obispo Creek, Pismo Creek, Arroyo Grande Creek) (NMFS 2013a: Recovery Actions CC-SCCCS-3.1 – 3.2; LO-SCCCS-3.1 – 3.2; SLO-SCCCS-3.1 – 3.2; Pis-SCCCS-3.1 – 3.2; AG-SCCCS-3.1 – 3.2.).
- Implement steelhead habitat restoration projects in the Morro Bay Complex (*e.g.,* Villa Creek Estuary Project, California San Luis Obispo National Guard Steelhead Management Plan, Santa Rosa Creek Water Conservation Project) (NMFS 2013a: Recovery Actions 8.1 DPS-Wide Recovery Actions; SR-SCCCS-1.1 – 1.3; 3.1 – 3.2).
- Complete and implement design for remediation of fish passage at the Marre Dam on San Luis Obispo Creek (NMFS 2013a: Recovery Actions SLO-SCCCS-4.1 – 4.3).
- Begin implementing the Updated Strategy for Steelhead Viability Monitoring in the Southern Coastal Area (Boughton *et al*. 2020) (NMFS 2013a: Recovery Actions 8.1 DPS-Wide Recovery Actions).

DPS Summary

The risk to the species' persistence has remained essentially the same since NMFS' 2016 5-year review, though a number of projects have been undertaken that have addressed specific issues in a number of core recovery watersheds noted above. However, major habitat concerns remain in this DPS particularly with regard to: (1) fish passage impediments in the mainstems of the major rivers and their tributaries; (2) the alteration of the natural flow regime as a result of dams, diversions and groundwater extraction; and (3) the presence of exotic aquatic species which can compete with native *O. mykiss*, as well as prey upon and transmit disease to native species. The loss and impairment of a substantial amount of the original estuarine habitat has further impacted the ability of anadromous *O. mykiss* to utilize these systems for rearing, acclimation, and ingress and egress to and from the ocean. The lack of adequate viability monitoring has also hampered the assessment of both the status of the South-Central California Coast Steelhead DPS and the effectiveness of recovery actions. Finally, the continued threat of prolonged drought, and the related frequency and magnitude of wildfires in response to climate changes present additional challenges to the existing remnant anadromous *O. mykiss* populations and their restoration to a level of sustainable recovery.

Listing Factor A Present or Threatened Destruction, Modification or Curtailment of the Species Habitat Range: Conclusion

South-Central California Coast steelhead have declined in large part as a result of agriculture, mining, and urbanization activities that have resulted in the loss, degradation, simplification, and fragmentation of habitat. Many of these threats are associated with the larger river systems such as the Pajaro, Salinas, and Carmel rivers and Arroyo Grande Creek. Many of these activities have also affected the smaller coastal systems such as Morro, San Luis Obispo, and Pismo creeks (NMFS 2013a).

Water storage, withdrawal, conveyance, and diversions for agriculture, flood control, and domestic purposes have greatly reduced or eliminated historically accessible steelhead habitat, and impaired the quality of remaining habitats throughout the watersheds. Modification of natural flow regimes by dams, diversions, and flood control structures have resulted in increased water temperatures, changes in fish community structures, reduced gravel recruitment, and depleted flows necessary for migration, spawning, rearing, estuarine functions, as well as flushing of sediments from spawning gravels. The substantial increase of impermeable surfaces resulting from urbanization (including roads) has also altered the natural flow regimes of rivers and streams, particularly in the lower mainstem reaches (Washburn *et al*. 2010); *see* also, National Research Council (2005), Cooper *et al.* (2013).

A significant percentage of estuarine habitats have been lost, particularly in the northern and southern portions of the DPS, where the majority of the wetland habitat historically occurred. The condition of these remaining wetland habitats is in many cases highly degraded, with many wetland areas at continued risk of loss or further degradation (NMFS 2013a).

There have been improvements to freshwater and estuary habitat conditions in portions of a number of watersheds because of recovery efforts undertaken by NMFS in collaboration with a wide variety of local, state and federal agencies and non-governmental partners. Historically blocked spawning and rearing habitat have been made more accessible by removal of a number of fish passage impediments. However, fish passage blockage at virtually all of the major dams in this DPS (with the notable exception of the removal of San Clemente Dam has not been effectively remediated; *see* Capelli (2007), Harrison *et al*. (2018), Swift *et al*. (2018), Boughton *et al*. (2018), Kock *et al*. (2020). While improvements to fish passage opportunities in selected portions of mainstem and tributary habitats should result in improved *O. mykiss* recruitment in the future, the improvements will not appreciably improve the long-term viability of the species without additional habitat restoration and recovery efforts, including establishing ecologically meaningful flow regimes and explicit consideration of the links between stream evolution, habitat, and ecosystems services (Cluer and Thorne 2013, Wohl 2021a, Wohl *et al.* 2021, Bellmore *et al*. 2019, California Department of Transportation 2019).

Habitat concerns remain in virtually all of the subbasins of the South-Central California Coast Steelhead DPS. The prolongation of (or more frequent and extended) drought conditions, coupled with more frequent and extensive wildfires (and consequent degradation of riparian habitat and water quality) exacerbates the threats to the South-Central California Coast Steelhead DPS. There remain numerous opportunities for habitat restoration or protection throughout the South-Central California Coast Steelhead DPS. Additional habitat protection or restoration actions are essential to buffer individual populations against a variety of anthropogenic threats (including climate change) as well as to restore the viability of the populations in the South-Central California Coast Steelhead DPS (Capelli 2015, 2021).

NMFS therefore concludes that the risk to the species' persistence has remained essentially the same, though habitat conditions (particularly regarding stream flows and fish passage) has improved since NMFS' 2016 5-year review. However, an extended drought coupled with extensive wildfires has temporarily curtailed migratory opportunities, degraded rearing habitat, and further depleted anadromous and resident *O. mykiss* populations within the South-Central California Coast Steelhead DPS. Future 5-year reviews would benefit from a systematic review and quantitative analysis of the amount of habitat (especially over-summering refugia habitat) within the core recovery watersheds targeted for protection and restoration activities in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a). This would enable managers to track habitat restoration progress, including recovery plan goals and objectives. Also, important will be the implementation of the updated strategy for steelhead viability monitoring in the South Coastal Area (Boughton *et al*. 2022b) to assess the current status of individual core recovery populations and the South-Central California Coast Steelhead DPS as a whole.

Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes

Harvest Effects

Steelhead populations traditionally supported an important recreational fishery throughout their range in south-central California (Fry 1938, 1973, Kreider 1948, CDFW 1999, NMFS 2013a). Recreational angling for both winter adult steelhead and summer rearing juveniles remains a popular sport in many coastal rivers and streams, but began to decline in the mid-1970s. Figure 20 depicts a typical winter steelhead angler in the San Simeon Creek Estuary.

Recreational angling in coastal rivers and streams for native steelhead can add to the mortality of adults (which represent the current generation of brood stock) and juveniles (which represent the future generations of brood stock) and may have contributed to the decline of some naturally small populations but is not considered the principal cause for the decline of the species as a whole. During periods of decreased habitat availability (*e.g*., drought conditions or summer low flow when fish are concentrated in freshwater habitats), the impacts of recreational fishing or harassment on native anadromous stocks have been heightened (NMFS 2013a).

Figure 20. Winter steelhead angling in San Simeon Creek Estuary. January 9, 2011. Photo: Mark H. Capelli, National Marine Fisheries Service.

Following NMFS' listing of populations of steelhead in California in 1997, CDFW began the process of closing angling in the anadromous waters throughout the state in 1998. Despite the listing of the South-Central California Coast Steelhead DPS as threatened under the ESA, CDFW continues to allow recreational angling for *O. mykiss* in all coastal drainages in south-central California (and in areas above currently impassable barriers). NMFS has previously concluded that recreational harvest is a limiting factor for South-Central California Coast Steelhead (Busby *et al.* 1996, Good *et al.* 2005). Angling for both adults and juveniles in those portions of coastal rivers and streams accessible to anadromous runs from the ocean has been generally restricted through modification of CDFW's angling regulations (*i.e.,* angling only below the first road crossing above the estuary, limited to three days a week, with artificial, single barbless hooks, and catch and release only); however, upstream of Los Padres Dam on the Carmel River anglers are allowed to retain up to two *O. mykiss* per day that fall between 10 and 16 inches. CDFW changed the recreational regulation for the Big Sur River in 2015 to reduce the summer trout season possession limit for the upper watershed from two steelhead or trout to no retention of any fish. However, no Fishery Management and Evaluation Plan has been approved by NMFS and the fisheries are not currently authorized under the ESA (CDFW 2015-2022).

Poor reporting of steelhead report card data and other data deficiencies precludes a rigorous assessment of recreational harvest impacts (Jackson 2007, CDFW 2016a). While insufficient data exists to estimate freshwater exploitation rates of South-Central California Coast steelhead populations, these rates are likely relatively low given California's statewide prohibition of capture and retention of natural-origin steelhead since 1998, and the tightly regulated and limited sport fishery within the South-Central California Coast Steelhead DPS. Fishing effort estimates based on angler self-report cards are available for 1993-2014 that suggest low levels of effort in this DPS over this period, though the estimates only reflects what is reported through report cards and creel surveys. Although fishing effort estimates for more recent years are not available, there has been no change in the authorized fishing opportunities during this period. However, there has been an increase in outdoor recreational activities, including angling, during the COVID-19 pandemic, and anecdotal reports of unauthorized recreational angling (W. Stevens, personal communication); as a result, the impacts of recreational sport fishing is not accurately known, but possibly underestimated. Figure 21 depicts the Distribution of California statewide steelhead angling effort by DPS for the years 2014-2022, with steelhead angling in the South-Central California Coast Steelhead DPS comprising less than 2 percent of the total statewide steelhead angling effort.

Sport and commercial harvest of steelhead in the ocean is prohibited by the CDFW (CDFW 2015-2022) and believed to be an insignificant source of mortality for south-central California steelhead populations. High seas driftnet fisheries in the past may have contributed slightly to a decline of this species in local areas, although steelhead are not targeted in commercial fisheries and reports of incidental catches are rare. Incidental ocean harvest of steelhead is rare (Burgner *et al*. 1992), and commercial fisheries are not believed to contribute to the large declines in abundance observed along most of the Pacific coast over the past several decades; *see* also, Grimes *et al*. 2007.

In summary, while recreational angling in coastal rivers and streams for native steelhead has increased the mortality of adults and juveniles, and may have contributed to the decline of some naturally small populations, this activity is not considered the principal cause for the decline of the species as a whole in the South-Central California Coast Steelhead DPS (NMFS 2013a). Further, there is no documented post-2016 information regarding the level of south-central California steelhead fishery impacts. NMFS therefore concludes that the level of harvest impacts is low, and the level of impact has not appreciably changed since NMFS' 2016 5-year review for the South-Central California Coast Steelhead DPS (Boughton 2022 in SWFSC 2022).

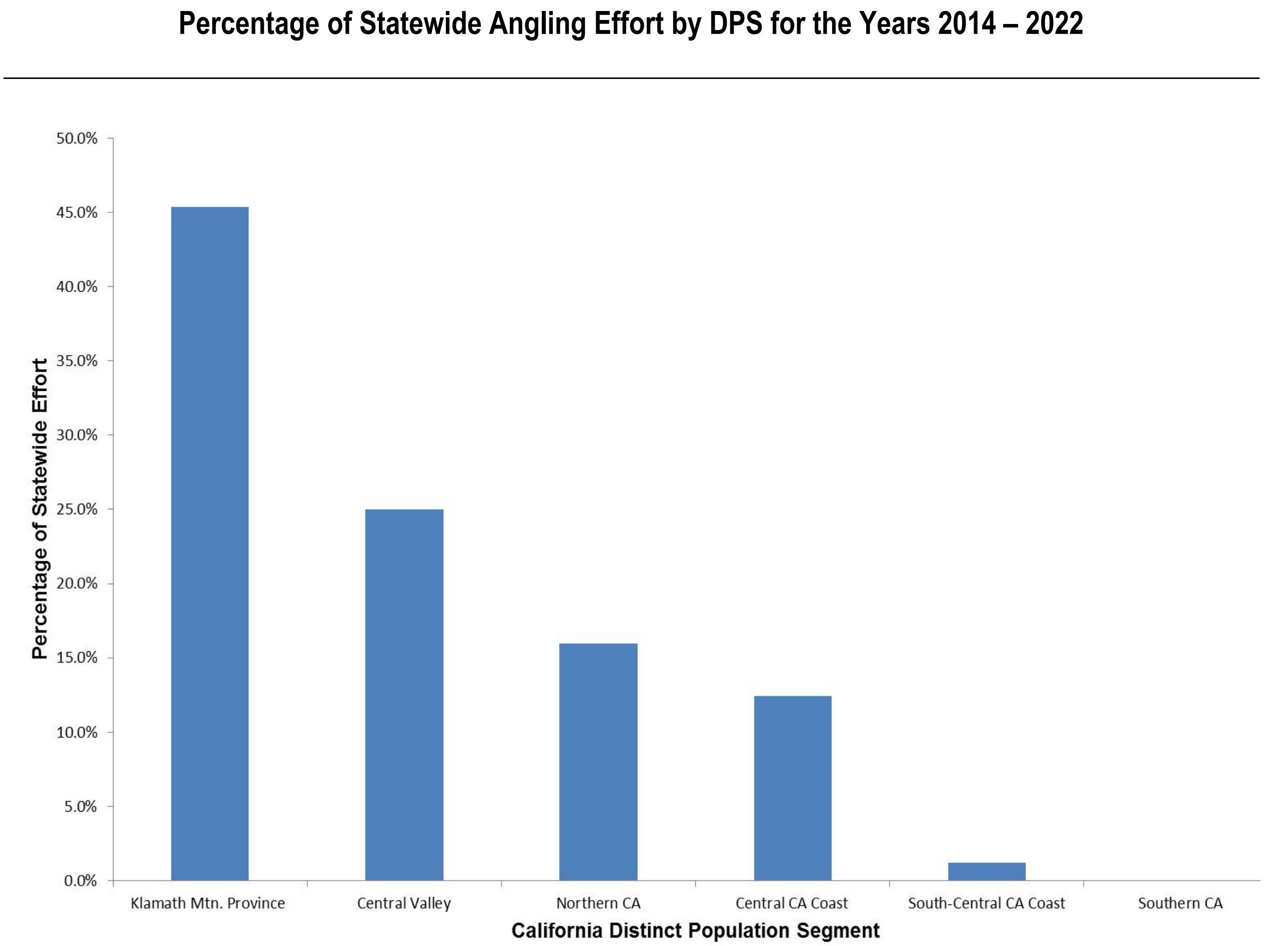

Figure 21. Distribution of California statewide steelhead fishing effort by DPS for years 2014-2022. California Department of Fish and Wildlife (provisional data).

Research and Monitoring

The exempted take of fish in the threatened South-Central California Coast Steelhead DPS authorized under ESA Section 10(a)(1)(A) and Section 4(d) for current scientific research and monitoring remains low, and much of the scientific research and monitoring being conducted is intended to fulfill managers' obligations under the ESA to ascertain the of the species. However, additional research and monitoring in a number of areas is essential to the effective recovery and management of the southernmost steelhead populations in California; these include, viability metrics; life history strategies; nursery habitats (including mainstems and estuaries); interactions between steelhead and non-native species; and the genomic characteristics (including the role in anadromy/residency) of southernmost steelhead populations in California steelhead (Boughton and Capelli 2014, Campbell *et al*. 2021, Waples *et al*. 2022, Boughton *et al*. 2022b). The importance of using genomic data in developing recovery strategies to preserve polymorphic species with geographically distinguishable phenotypes is increasingly recognized by researchers investigating threatened or endangered species; see, for example, Turba *et al.* (2022). See additional areas of research identified under "Listing Factor C: Disease and Predation."

Exempted mortality rates associated with current scientific research and monitoring are generally capped at no greater than 0.5 percent across NMFS' West Coast Region for all listed salmon ESUs and steelhead DPSs. As a result, the mortality levels that research causes are very low throughout the region. In addition, and as with all other listed salmonids, the effects research has on the south-central California steelhead populations are spread out over various reaches, tributaries, and areas across the species' ranges, and thus no area or population is likely to experience a disproportionate amount of loss. Therefore, the research programs, as a whole, have only a very small impact on overall population abundance, a similarly small impact on productivity, and no detectable effect on spatial structure or diversity.

From 2015 through 2019, researchers were granted exemptions to take a yearly average of fewer than 323 adult steelhead (< 8 lethally) and fewer than 49,000 juvenile steelhead (< 1,200 lethally) within coastal watersheds of the South-Central California Coast Steelhead DPS (NMFS APPS database; https://apps.nmfs.noaa.gov/). For the vast majority of scientific research permits, history has shown that researchers generally take far fewer salmonids than the number exempted every year. From 2015 through 2019, there was no actual take (lethal or non-lethal) of adults reported for steelhead within the South-Central California Coast Steelhead DPS. During that same period, the total yearly average reported juvenile take was only 17 percent of the annual average exempted take (*i.e.*, < 8,100 juvenile steelhead captured or handled and < 38 steelhead killed per year, on average).

The majority of the requested take of juvenile steelhead within the South-Central California Coast Steelhead DPS has been (and is expected to continue to be) capture via screw traps, electrofishing units, beach seines, fyke nets, hand or dip nets, and at weirs, with smaller numbers being captured via gill nets, minnow traps, and hook and line angling. Adult take has primarily been (and is expected to continue to be) requested as capture via hook and line angling, hand or dip nets, and fyke nets, with smaller numbers being captured by weirs, trawls, and other seine or trap methods intended to target juveniles (NMFS APPS database; https://apps.nmfs.noaa.gov/). NMFS' records indicate that mortality rates for screw traps are typically less than 1 percent and backpack electrofishing typically less than 3 percent. Unintentional mortality rates from seining, hand or hoop netting, fyke nets, minnow traps, weirs, and hook and line methods are limited to no more than 3 percent. In addition, a small number of adult fish may die as an unintended result of research because of interactions with trawl or gill net sampling equipment.

The quantity of take exempted over the past 5 years has increased within the South-Central California Coast Steelhead DPS compared to the prior 5 years. Total take exempted for adults and juvenile steelhead from 2015 through 2019 was 59 percent higher than the total take exempted from 2010 through 2014. Lethal take exempted from 2015 through 2019 was also higher, with 165 percent more mortalities exempted for the South-Central California Coast Steelhead DPS than previously exempted from 2010 through 2014. Actual take that occurred from 2015 through 2019 was also higher than the previous 5 years, with reported total take increasing 65 percent and lethal take increasing 30 percent compared to 2010 to 2014, although absolute numbers remain low (*i.e*., the lethal take that occurred over 5 years increased from a total of 143 to 186 individuals between these two time periods).

Overall, research (and monitoring) impacts remain minimal due to the low mortality rates authorized under research permits and the fact that research is spread out geographically throughout the watersheds of the South-Central California Coast Steelhead DPS. In addition, despite the increases in the amount of take requested by researchers and authorized by NMFS West Coast Region, the actual amount of take occurring has remained low relative to abundance. Consequently, NMFS concludes that the risk to the species' persistence because of take related to scientific studies remains very low, and essentially unchanged since NMFS' 2016 5-year review (Williams *et al.* 2016, SWFSC 2022).

Listing Factor B Overutilization for Commercial, Recreational, Scientific or Educational Purposes: Conclusion

New information available since NMFS' 2016 5-year review indicates that harvest impacts for South-Central California Coast Steelhead DPS has not substantially changed. Scientific research impacts authorized through the West Coast Region from 2015 through 2019 have remained relatively unchanged compared to the prior 5 years (NMFS APPS database; https://apps.nmfs.noaa.gov/). The risk to the species' persistence because of overutilization remains essentially unchanged since NMFS' 2016 5-year review, with harvest and research/monitoring sources of mortality continuing to have no appreciable impact on the persistence of the South-Central California Coast steelhead DPS (SWFSC 2022).

Listing Factor C: Disease and Predation

Disease

Infectious disease is one of many factors that can influence adult and juvenile steelhead survival. Specific diseases such as bacterial kidney disease, *Ceratomyxosis*, *Columnaris*, *Furunculosi*s, infectious hematopoietic necrosis, redmouth and black spot disease, Erythrocytic Inclusion Body Syndrome, and whirling disease, among others, are present and are known to affect steelhead (Wood 1979, Noga 2000, Bartholomew *et al*. 2002, Miller *et al*. 2014, Schaaf *et al*. 2017, 2018). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases for steelhead. Warm water in some cases can contribute to the spread of infectious diseases. Artificially induced summer low-flow conditions may also benefit non-native aquatic species by increasing water temperatures favoring non-native warm water aquatic species, exacerbating the spread of diseases. However, studies have shown that native fish tend to be less susceptible to pathogens than hatchery cultured and reared fish (Buchanan *et al.* 1983, Bartholomew *et al*. 2002, Gilbert and Granath 2003, Granath and Vincent 2010, Miller *et al.* 2014); *see* also, Boughton *et al*. (2015). In general there is a dearth of research on the effects of disease on steelhead in the South-Central California Steelhead

Recovery Planning Area. This was one of several research topics identified in the National Center for Ecological Synthesis and Analysis (NCEAS) Southern steelhead research and monitoring colloquium (Boughton and Capelli 2014).

Predation

Non-Native Predators

The combination of non-native aquatic species introductions and habitat modifications (*e.g.*, dam impoundments, altered flow regimes, flood-control activities) have increased non-native predator populations in numerous river systems. Non-native species, particularly fishes and amphibians such as largemouth and smallmouth bass (*Micropterus* spp.) bullhead (*Ameiurus* spp.) channel catfish (*Ictalurus punctatus*), common carp (*Cyprinus carpio*), sunfish (*Lepomis* spp.) western mosquito fish (*Gambusia affinis*), flathead minnow (*Pimephales promelas*), Sacramento pikeminnow (*Ptychocheilus grandis*) and bullfrog (*Lithobates catesbeiana*), have been introduced and spread widely throughout south-central California (Moyle 1976, Dill and Cordone 1997, Towle 2000, Landres *et al*. 2001, Stebbins and McGinnis 2012, Stillwater Sciences 2017a, 2017b, 2018, 2019, 2021, Stillwater Sciences and Wilson 2018); *see* also, Jarrett *et al*. (2019). A non-native aquatic crustacean that has become widespread in California watersheds is the red swamp crayfish (*Procambarus clarkii*). These species can displace and prey upon native species, increasing the level of predation and competition for space for native fishes, including juvenile steelhead and related resident *O. mykiss.* They can also act as vectors for non-native diseases (Busby *et al.* 1996, Knapp and Matthews 200, Fritts and Pearson 2006, Cucherousset and Olden 2011, Klose 2011, 2012, Lawrence *et al.* 2012, Hubbartt 2019, Boughton 2020; D. Boughton, personal communication).

Low flow conditions and the presence of non-native aquatic species can increase avian predation by increasing prey numbers and concentrating native aquatic species. Striped bass (*Morone saxatilis*) have also been reported from near-shore waters, and within some estuaries within the South-Central California Coast Steelhead DPS, including the Carmel River (Allen *et al.* 2006, Boughton 2020; M. Love, personal communication).

A recent investigation of predation of Western gulls (*Larus occidentalis*) on juvenile steelhead indicates that modern predation risk is ~2.4 times higher than historically as a result of the increase in gull population due to concentrated greater artificial feeding opportunities resulting from man-made developments, including trash disposal facilities (Osterback *et al.* 2015). In general there is a dearth of research on the effects of non-native predation on steelhead in the South-Central California Steelhead Recovery Planning Area. This was one of several research topics identified in the National Center for Ecological Synthesis and Analysis (NCEAS) Southern steelhead research and monitoring colloquium (Boughton and Capelli 2014).

Marine Mammals

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 Northeast Pacific over the past few decades (Chasco *et al*. 2017a, Chasco *et al*. 2017b). The three main seal and sea lion (pinniped) predators of ESA-listed salmonids in the eastern Pacific Ocean are harbor seals (*Phoca vitulina richardii*), California sea lions (*Zalophus californianus*), and Steller sea lions (*Eumetopias jubatus*). With the passing of the Marine Mammal Protection Act (MMPA) in 1972, the abundance of these pinniped stocks along the West Coast of the U.S. has steadily increased (NMFS 2011a, Carretta *et al*. 2019). The current population size of California sea lions is within the range of its Optimum Sustainable Population (OSP) size (Carretta *et al.* 2019). Muto *et al.* (2021) concluded that the eastern stock of Steller sea lions is likely within its OSP range, but NMFS has made no determination of its status relative to OSP. The OSP status of the California stock and the Oregon and Washington Coast stock of harbor seals is also unknown.

With their increasing numbers and expanded geographical range, marine mammals are consuming more Pacific salmon and steelhead, and some are having an adverse impact on some ESA-listed species (Chasco *et al*. 2017a, Thomas *et al.* 2017, and Marshall *et al*. 2016). Whether increasing sea lion populations in Oregon and California are associated with decreased survival of south-central California steelhead populations through marine, estuarine and freshwater migration corridors is currently unknown, as there have not been similar survival assessments of populations in south-central California coastal estuaries/rivers to date. Similarly, no data for harbor seals are available so the extent of harbor seal impacts on the South-Central California Coast Steelhead DPS is similarly unknown. Research into this potential threat will be required to identify is nature, extent, and appropriate recovery actions.

Another issue is the expansion of the Northern elephant seal (*Mirounga angustirostris*) at Piedras Blanca near San Simeon (within the San Luis Obispo Terrace BPG) which seasonally gather near several small estuaries near San Simeon where juvenile steelhead rear. The interactions between Northern elephant seals and steelhead has not been the subject of systematic investigation within the South-Central California Coast Steelhead DPS and its significance is therefore unknown. However, rearing juvenile Northern elephant seals feed almost exclusively on the females' milk and are not known to pursue prey prior to entering the marine environment. (Radford *et al.* 1965, Reiter *et al*. 1978, Cooper 1983, Beddington *et al*. 1985. DeMaster *et al.* 1985, Lowry *et al.* 1987, 1996, Stewart and Huber 1993, United States General Accounting Office 1993, Le Boeuf and Laws 1994, Antonelis *et al.* 1994, Stewart *et al.* 1994, Le Boeuf 1996, Fresh 1997, Yurk and Trites 2000, Lowry 2002, Hinton 2003, Middlemas *et al*. 2005, Steele and Anderson 2006; B. Le Boeuf, personal communication).

Listing Factor C Disease and Predation: Conclusion

NMFS concludes that the information available on these impacts to steelhead did not suggest that the South-Central California Coast Steelhead DPS was in danger of extinction, or likely to become so in the foreseeable future, because of predation or disease, though the severity of this threat is likely to increase unless effective measures are taken to abate it (Boughton 2022 in SWFSC 2022). However, it is recognized that small populations of steelhead within the South-Central California Coast Steelhead DPS can be more vulnerable to extinction through the synergistic effects of other threats. For example, the role of disease or predation may be heightened under conditions of periodic low flows or high water temperatures exacerbated by the operation of dams, diversion, and groundwater extraction programs; and these conditions are exacerbated by the prolonged drought, and potentially by projected climate change, making specific populations more vulnerable to disease and/or predation.

These threats have remained essentially the same over the previous 5 years, though individual, site-specific threats may have been reduced or eliminated as a result of conservation actions (*e.g.*, through the restoration of flows or riparian habitats which affect water temperature), or conversely increased as a result of deteriorating local conditions (*e.g.*, as a result of wildfires and related impacts such as elevated erosion and sedimentation rates and/or degradation of instream or riparian vegetation). Additional research into the effects of non-native predators (and disease), and marine mammal predation, on the core recovery populations with the South-Central California Steelhead Recovery Planning Area is necessary to better understand these threats and to focus related recovery actions. Because south-central California steelhead are listed as threatened research that involves handling or disturbing this species or its habitat will require take coverage under the regulatory provisions of the ESA.

Listing Factor D: Inadequacy of Regulatory Mechanisms

Various federal, state, county, and city regulatory mechanisms exist to reduce habitat loss and degradation caused by human land uses and water development, as well as harvest impacts. For the 5-year review, NMFS focused the analysis on regulatory mechanisms for habitat in the South-Central California Coast Steelhead DPS because inadequate regulation of land and water uses has resulted in the significant loss or degradation of habitat, which is the most significant threat to steelhead populations in south-central California.

Habitat concerns are described throughout Listing Factor A as having either a watershed-wide influence, or more localized influence, on the core recovery populations and BPGs that comprise the South-Central California Coast Steelhead DPS. The habitat conditions across all habitat components (tributaries, mainstems, estuary, and the marine environment) necessary to recover the South-Central California Coast Steelhead DPS are influenced by a wide array of federal, state, and local regulatory mechanisms. The underlying ownership (either federal, state, private, or tribal) of land and water resources controls in large degree the role of regulatory mechanisms on listed salmon and steelhead and their habitats.

One factor affecting habitat conditions across all land or water ownerships is climate change, the effects of which are discussed in Section 2.3.2 “Listing Factor E: Other Natural or Manmade Factors Affecting its Continued Existence.” NMFS reviewed national and international regulations and agreements governing greenhouse gas emissions, which indicate that the number and efficacy of these mechanisms has increased in recent years. However, recent climate assessments have not shown a substantial reduction in global emissions (IPCC 2014, IPCC 2018, 2021). These findings suggest that current regulatory mechanisms, both in the 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. An upscaling and acceleration of local, state, national, and international efforts will therefore be needed to reduce future climate-related risks to West Coast salmon and steelhead, including the South-Central California Coast Steelhead DPS.

Information available since NMFS' 2016 5-year review indicates that the adequacy of a number of land use and water development regulatory mechanisms has improved, though this has not been comprehensively documented because of the large number of local, regional, state and federal regulatory actions conducted within the range of the South-Central California Coast Steelhead DPS. The development of NMFS' 2013 South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) and designation of critical habitat has provided significant guidance for recovery of the core recovery populations throughout the South-Central California Coast Steelhead Recovery Planning Area and served to inform the preparation of environmental documents under both the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). NEPA and CEQA provide the fundamental environmental information that informs a majority of land use, water planning, and regulatory decisions at the federal, state, and local levels. Additionally, the application of the ESA's Section 7 and Section 10 statutory processes has substantially enhanced the regulatory oversight of projects affecting steelhead or designated critical habitat within the South-Central California Coast Steelhead DPS. The passage of SGMA in 2014 has provided a new regulatory mechanism for managing groundwater resources that have been identified as a major issue in the restoration of core recovery populations within the South-Central Coast California Steelhead DPS. Implementation of NMFS' recovery actions is an on-going process.

NMFS remains concerned, however, about the adequacy of existing habitat regulatory mechanisms, particularly with regard to: (1) water rights allocation, instream flow rules, and agricultural and domestic wells—each of which reduces available stream flows, limits habitat connectivity, and affects water quality (*e.g.*, increasing water temperature and lowering dissolved oxygen); (2) floodplain management (including maintenance activities) and levees that constrain floodplain connectivity, degrade riparian conditions, and habitat complexity and interrupt habitat forming processes; and (3) land uses (including extensive road networks, residential, industrial, agricultural, and recreational developments), that elevate sediment loads, erode stream banks, and impact riparian vegetation; *see*, for example, Capelli (2018c), Wohl (2021a), Wohl *et al*. (2021). Many of these activities fall within the jurisdiction of federal and non-federal land and water planning and regulatory programs that are described below.

Land and Water Management

A portion of the South-Central California Steelhead Recovery Planning Area is in either federal or state ownership (c. 19%). Additional public lands are owned or managed by City and County local governments, or special districts. The amount of public and private ownership varies considerably within each of the 4 BPGs that comprise the South-Central California Coast

Steelhead DPS. Table 9 provides the percentages of federal, state and tribal land ownership (arranged by BPGs) within the South-Central California Coast Steelhead DPS, with much of the federal lands located within the Los Padres National Forest.

Table 9. Federal, State and Tribal Land Ownership: South-Central California Coast Steelhead DPS

BPG	Federal Lands	State Lands	Tribal Lands
Interior Coast Range	15.5%	1.23%	0%
Carmel River Basin	1.3%	0.88%	0%
Big Sur Coast	57.8%	9.3%	0%
San Luis Obispo Terrace	9.43%	6.33%	0%

Source: https://gis.water.ca.gov/arcgis/rest/services/Boundaries/i03_FederalLands/FeatureServer

The amount of urbanized land within the South-Central California Steelhead Recovery Planning Area is relatively uniform between BPGs, with the most sparsely developed lands occurring in the middle section, and the most densely developed lands occurring in the north and south. The following presents the percentage of urban developed land area within each of the South-Central California Steelhead BPGs:

- Interior Coast Range BPG: 3 percent
- Carmel River Basin BPG: 4 percent
- Big Sur Coast BPG: 1 percent
- San Luis Obispo Terrace BPG: 5 percent

Much of the undeveloped landscape within the South-Central California Steelhead Recovery Planning Area consists of mixed oak woodland and introduced grasslands, with the Big Sur Coast containing relict coniferous redwood forest, and other coniferous species such as the endemic Santa Lucia fir (*Abies bracteata*). There are significant irrigated agricultural developments within coastal and interior valleys (*e.g.*, Pajaro, Salinas, Carmel), and along the southern coastal terrace, adjacent to major river drainages mixed with urban development generally concentrated in valley bottoms, and along the coast—with the notable exception of the Big Sur Coast (NMFS 2013a, Hunt and Associated 2008).

At the time of the original listing of the South-Central California Coast Steelhead ESU in 1997, several federal and state regulatory and planning mechanisms were available to aid in the conservation of steelhead populations within the South-Central California Steelhead Recovery Planning Area; additional programs have subsequently been instituted. The most relevant are described below.

Federal Programs

Endangered Species Act Provisions (ESA)

Section 7 of the ESA requires each federal agency, in consultation with the Secretary of Commerce, to ensure that any action authorized, funded, or carried out is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction of adverse modification of critical habitat, unless otherwise exempted. Additionally, Section 10(a)(1)(A) of the ESA provides that the Secretary of Commerce may permit, under specified terms and conditions, actions otherwise prohibited by Section 9 of the ESA[15] for scientific purposes or to enhance the propagation or survival of any listed species, while Section 10(a)(1)(B) provides for the taking of listed species otherwise prohibited by Section 9 if such taking is incidental to, and not the purpose of, carrying out an otherwise lawful activity, as part of a Habitat Conservation Plan (HCP). NMFS has used these and other regulatory mechanisms to help further the conservation and recovery of the South-Central California Coast Steelhead DPS, and they therefore continue to reduce the risk of steelhead habitat loss and degradation of steelhead habitats in the South-Central California Coast Steelhead DPS.

For example, NMFS has issued a number of biological opinions addressing fish rescue, passage and maintenance activities on the Los Padres National Forest, for the following projects within the South-Central California Coast Steelhead DPS:

- Carmel River Lagoon Sandbar Management Plan
- Carmel River Steelhead Rescue and Rearing Enhancement Program
- Arroyo Grande Creek Waterway Management Program
- U.S. Forest maintenance activities on the Los Padres National Forest

NMFS continues to work with the action agencies on implementing the reasonable and prudent measures and alternatives, as well as conservation measures identified in these biological opinions (NMFS 2013a, 2013b, 2017a, 2019b, 2019c, 2019d, 2019e, 2019g); *see* also, NMFS (2018a, 2018b, 2019f, 2019h). NMFS has also consulted with the U.S. Forest Service for the aerial application of fire retardant on the National Forest System Lands within the jurisdiction of the NMFS' West Coast Region (NMFS 2018b); *see* also, NMFS (2018a). The U.S. Forest Service has prepared a Draft Supplemental Environmental Impact Statement which supplements portions of the 2011 Nationwide Aerial Application Fire Retardant Final Environmental Impact Statement; this supplement will analyze potential impacts associated with new aerial retardant

[15] Among the prohibited actions identified in the ESA is the "take" of any federally listed threatened or endangered species. Take is defined as: "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct." ESA Section 3(19) 16 U.S.C. Section 1532(19). Harm is further defined by regulation as an act that actually kills or injures fish or wildlife. Such an act may include significant habitat modification or degradation which actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering. 50 C.F.R 222.102.

chemicals and information regarding aerial retardant use since 2011 and is intended to update Interagency Wildland Fire Chemical Policy Guidance (U.S. Forest Service 2022).

NMFS also issued a biological opinion to NOAA's Restoration Center in 2015 to cover restoration projects funded by the Restoration Center, or projects that require a Section 404 permit from the USACOE that are determined by the Restoration Center to be within the scope of the program (NMFS 2015b). To qualify for take coverage under this biological opinion, all proposed restoration projects must satisfy one or more of the following objectives: (1) restore degraded steelhead habitat; (2) improve instream cover, pool availability, and spawning gravel; (3) remove barriers to fish passage; and (4) reduce or eliminate sources of erosion and sedimentation. Due to the evolving nature of the various techniques and guidelines for salmonid restoration, NOAA's Restoration Center requires that projects authorized under this program must adhere to the best management practices and the most current guidelines and techniques for design and implementation of projects.

Initial studies have been initiated for an HCP to cover the operation of the Monterey County Water Management Agencies dam and reservoir operations within the Salinas River watershed (including the Salinas River Diversion Facility), and for sandbar management at the Salinas River Estuary; *see* also, U.S. Bureau of Reclamation (2015).

National Oceanic and Atmospheric Administration Fisheries Office of Law Enforcement (OLE)

NOAA's Office of Law Enforcement (OLE) protects marine wildlife and habitat by enforcing domestic laws and supporting international treaty requirements designed to ensure global resources are available for future generations. OLE is the only federal law enforcement agency fully dedicated to the enforcement of federal fishery regulations. OLE's special agents, enforcement officers, as well as investigative and mission support staff, provide stakeholders with compliance assistance and education about the nation's marine and anadromous fishery resource laws.

OLE directly supports the core mission mandates of NMFS—maximizing productivity of sustainable fisheries and fishing communities, as well as the protection, recovery, and conservation of protected species—through its efforts to enforce and promote compliance with the marine resource protection laws, including the ESA, and implementing regulations under NOAA's purview. Special Agents and Enforcement Officers use officer discretion when deciding whether or not to provide Compliance Assistance by educating the alleged violator regarding a detected violation or to issue a Summary Settlement; Written Warning; Fix-It Ticket; or refer a completed investigation for administrative, civil or criminal prosecution.

OLE jurisdiction generally covers ocean waters between 3 and 200 miles offshore and adjacent to all U.S. states and territories, which comprise the Exclusive Economic Zone (EEZ). The OLE jurisdiction includes:

- 3.36 million square miles of open ocean

- More than 95,000 miles of U.S. coastline
- 14 National Marine Sanctuaries and 5 Marine National Monuments
- All anadromous waters included within the range of federally protected species

OLE conducts enforcement activities: through patrols, both on and off the water, as well as monitoring vessels electronically; criminal and civil investigations; partnerships with state, tribal, federal, and nongovernmental organizations; outreach and compliance assistance; and the use of innovative technological tools.

Within the South-Central California Coast Steelhead DPS, OLE personnel focus on watersheds essential for species recovery identified in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a). NMFS' staff works closely with OLE regarding the identification of threats and other activities believed to place steelhead at high risk of take. Enforcement of ESA take prohibitions remain unchanged since the last 5-year review; however, the level of enforcement staffing, investigative activity, and follow-up continues to be insufficient to adequately protect the South-Central California Coast Steelhead DPS from unauthorized take. Annually reviewing and updating the prioritization of potential investigations, and expanding OLE's public information and outreach activities would also enhance the enforcement of ESA take prohibitions.

Pacific Coastal Salmon Recovery Fund (PCSRF)

The United States Congress (Congress) established the PCSRF in 2000 to support the conservation of Pacific salmon and steelhead populations and the habitats upon which they depend. The States of California Oregon, Washington, Idaho and Alaska and the Pacific Coastal and Columbia River tribes have received Congressional PCSRF appropriations from NMFS each year since Fiscal Year 2000. The PCSRF is used to support projects carried out by state agencies, local governments, public partners, watershed councils, soil and water conservation districts, tribes, private landowners, and a variety of non-governmental organizations. The program provides substantial funding through competitive grants programs administered by the individual states, and is considered essential to preventing the extinction of the 28 listed salmon and steelhead species on the West Coast. The PCSRF is also used to leverage additional state and local funds and volunteer participation from local and private sources of funding; since 2000, PCSRF has received over $1.3 billion in Congressionally authorized funds and leveraged nearly $1.7 billion in non-PCSRF contributions (NOAA Fisheries 2020b); *see* also, NMFS (2019a). Figure 22 depicts the annual distribution of PCSRF funds by state (Idaho, Oregon, California, Alaska, and Washington) and tribes (Columbia River Tribes and Pacific Coastal Tribes) from 2000-2019.

PCSRF priorities include: (1) projects that address factors limiting the productivity of Pacific salmon and steelhead listed under the ESA, including priority actions specified in the species approved ESA recovery plans, and those populations necessary for the exercise of tribal treaty fish rights or native subsistence fishing; (2) effectiveness monitoring or habitat restoration actions at the watershed or larger scales for ESA-listed salmon and steelhead, and status monitoring projects that directly contribute to population viability assessments for ESA-listed salmon and steelhead, or monitoring necessary for the exercise of tribal treaty rights or native subsistence fishing on salmon and steelhead; and (3) other projects consistent with the Congressional authorization with demonstrated need for PCSRF funding; this includes projects that are necessary precursors to implementing activities under the above priorities, including public outreach, planning, coordination, assessment, research, and monitoring, or other engineering design projects (NOAA Fisheries 2020a).

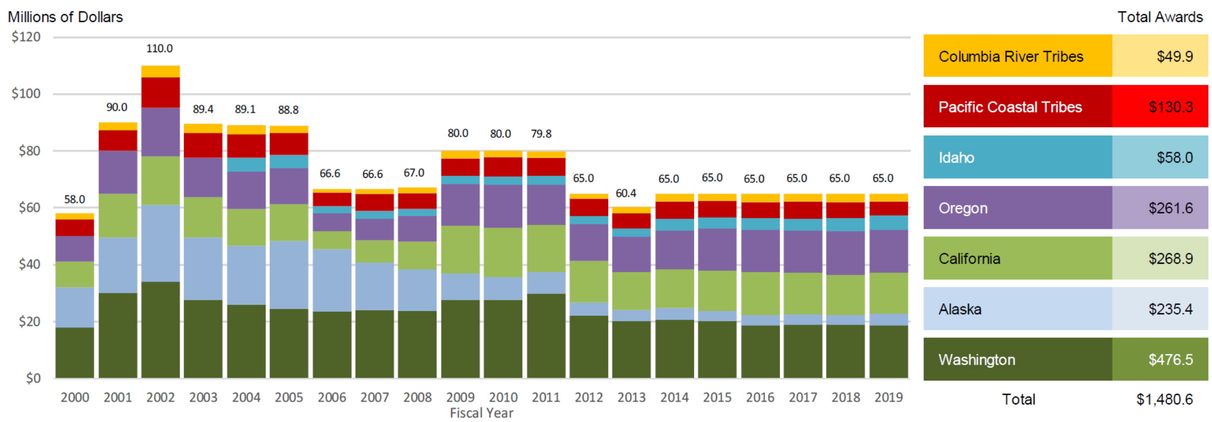

Figure 22. Distribution of Pacific Coast Salmon Restoration Funds 2000–2019 (NOAA Fisheries 2020a).

In California, the PCSRF appropriations (and other nonfederal derived monies) are administered through the California Department of Fish and Wildlife's Fisheries Restoration Grant Program (FRGP) and other related grant programs. Funding of projects through PCSRF has remained relatively stable since 2016, and has made substantial contributions to the remediation of habitat loss or degradation and, therefore, to the recovery anadromous salmonids listed under the ESA. For a description of this program and other funding programs; *see* the discussion in "Non-Federal Program, Fisheries Restoration Grant Program."

Federal Power Act (FPA)

The Federal Power Act (FPA) requires hydropower project owners to obtain a license from the Federal Energy Regulatory Commission (FERC). Many hydropower dams block access to historic upstream salmon and steelhead spawning and rearing habitats and prevent or inhibit the downstream movement of genetically related salmon and steelhead to the ocean. Additionally, these facilities trap spawning gravel and woody debris, and generally alter the natural flow regime that creates and maintains spawning, rearing, and refugia habitats for salmon and steelhead.

The FPA authorizes NMFS to issue mandatory improvements for fish passage (pursuant to FPA Section 18) and to recommend other measures (pursuant to FPA Sections 10(a) and 10(j)) to protect anadromous salmon, steelhead, and sturgeon and to improve their habitats.

FERC consults with NMFS on the re-licensing of non-federal hydroelectric projects as well as marine energy projects in the Pacific Ocean, offshore of Washington, Oregon, and California. FERC has several types of licensing/re-licensing processes that are used to guide the collection of data, development of a license application, and the issuance of a license. NOAA Fisheries' California Central Valley Office's (CCVO) FERC Branch deals with FERC projects in California (primarily in Central Valley watersheds, but in other regions as well, including the South-Central California Coast Steelhead Recovery Planning Area and with marine energy projects in California (with assistance from the California Coastal Office). FERC licenses are issued for 30-50 years, and therefore represent a long-term commitment of water resources, with potential long-term consequences for the affected watersheds and their anadromous fisheries.

NOAA Fisheries staff develops standards for upstream and downstream fish passage as well as recommends measures for the improvement to water quality, spawning gravel, and other important features of salmon and steelhead habitats. NMFS' FERC Branch has been participating in 28 active projects in California during the 2016-2020 period. However, none of the FERC projects has completed their license process. Therefore, no proposed protection, mitigation, and enhancement conditions that would protect and restore NMFS' public trust fishery resources, including salmon and steelhead, have been implemented. As a result, all of the current FERC regulated facilities and operations, under their existing FERC licenses, have continued to negatively impact public trust fishery resources and degrade their habitats, and the risk to the South-Central California Coast Steelhead DPS has not been appreciably reduced.

NMFS' West Coast Region FERC projects website includes FERC projects in California, Oregon, and Washington. These can be accessed at: (https://www.fisheries.noaa.gov/west-coast/habitat-conservation/west-coast-federal-energy-regulatory-commission-licensed).

National Flood Insurance Program (NFIP)

The 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 continued to be a concern because it facilitates development in floodplains without mitigation for impacts on natural habitat values.

All Pacific salmon and steelhead species listed under the ESA are negatively affected by an overall loss of floodplain habitat connectivity and complex channel habitats. The reduction and degradation of habitat has progressed over decades as flood control and wetland filling has 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 of most ESA-listed salmonids. NMFS believes altering and armoring stream banks, removing riparian vegetation, constricting channels and floodplains, and regulating flows are primary causes of anadromous fish declines (65 FR 42450), and activities affecting this habitat include wetland and floodplain alteration which reduces and simplifies important off-channel rearing habitat (64 FR 50414); *see* also, Wohl (2021a, 2021b,) Wohl *et al.* (2021), Skidmore and Wheaton (2022).

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 stream from functioning property and result in degraded habitat. Most communities (counties, cities, and towns) in California are NFIP participating communities, applying the NFIP minimum criteria. For this reason, it important to note that the NFIP minimum standards have been found to jeopardize 18 listed species of salmon and steelhead (NMFS 2008, 2016c)

The NFIP has not been specifically evaluated for its effects on the endangered South-Central California Coast Steelhead DPS. However, because Pacific salmon and steelhead share many habitat requirements, it is likely that the NFIP systematically allows a pattern of adverse effects that individually and cumulatively diminish floodplain habitat values (*e.g*., habitat connectivity, complexity, hyporheic connection, stream flow recharge, and refugia and feeding opportunities) for this ESA-protected species; *see*, for example, Richmond *et al*. (2017), NMFS (2019b), Wohl *et al*. (2021a, 2021b), Wohl *et al*. (2021), Skidmore and Wheaton (2022). Therefore, the NFIP program continues to allow floodplain development to degrade steelhead habitats and threaten the South-Central California Coast Steelhead DPS.

Clean Water Act (CWA)

The Federal Clean Water Act (CWA) addresses a wide variety of water issues, including the development and implementation of water quality standards, the development of Total Maximum Daily Loads (TMDLs)[16], filling wetlands, point source waste discharges, and regulation of stormwater runoff for the protection of waters of the U.S. The California Clean Water Act (CCWA) is administered by the State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Boards (RWQCB), with oversight by the U. S. Environmental Protection Agency (EPA). State water quality standards are set to protect recognized beneficial uses of waters, which include several categories of salmonid use (*e.g.*, migration, spawning,

[16] A TMDL standard 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 standard 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.

etc.). Together the state and federal clean water acts regulate the allowable level of pollution within streams and rivers in California.

The State of California administers a Section 401 water quality certification program that reviews projects that will discharge dredged or fill materials into waters of the U.S.[17] The purpose of the 401 program is to ensure that proposed projects meet State water quality standards and other aquatic protection regulations. California also issues National Pollution Discharge Elimination System (NPDES) permits under Section 402 for discharges from industrial point sources, wastewater treatment plants, construction sites, and municipal stormwater conveyances. The 402 permits establish parameters for the allowance of mixing zones if the discharged constituent(s) do (es) not meet existing water quality standards.

TMDL standards are established for individual watersheds to reduce concentrations of specific contaminants or natural constituents recognized within a waterbody[18] that fail to meet water quality standards in repeated testing. These contaminants may be pesticides such as dieldrin that is regulated under the Federal Insecticide, Fungicide and Rodenticide Act, industrial chemicals such as polychlorinated biphenyls regulated under the Toxic Substances Control Act,[19] or other physical parameters such as water temperature for which numeric water quality standards have been developed. Numerous toxicants have yet to be addressed in TMDL standards.

Recent research has identified stormwater runoff from roadways causing significant mortalities in salmonids (McIntyre *et al*. 2018). One source of roadway runoff pollution is the degradation of tire components, including 6PPD-Quinone (the molecule created when 6PPD reacts with ozone), with concentrations as low as one part per billion (Tian *et al*. 2021). This contaminant is widely used by tire manufacturers and tire dust has been found where urban and rural roadways drain into waterways (Feist *et al*. 2017, Sutton *et al.* 2019); *see* also, Booth and Jackson (1997), Booth *et al*. (2002), McBride and Booth (2005), Aguilera and Melack (2018). Urban (and agricultural) runoff has been identified in all south-central California steelhead BPGs as one of the key emergent or ongoing habitat concerns since the last 5-year review. However, research on stormwater runoff from roadways, and the effects of urban runoff in general, has not been the subject of extensive investigation in south-central California.

The USACOE issues Individual, Nationwide and Emergency permits for the dredging and the

[17] The EPA and the USACOE have published a proposed rule defining the scope of water protected under the Clean Water Act, consistent with the Executive Order signed on January 20, 2021 on "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis" which directed agencies to review the agencies' rule promulgated in 2020 defining "waters of the Unites States". (86 FR69372)

[18] Under §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 waters 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.

[19] The Toxic Substances Control Act (TSCA) of 1976 provides EPA 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.

placement of fill within the waters of the U.S. under Section 404 of the CWA. Permitted activities are not permitted to cause or contribute to significant degradation of the waters of the U.S. (86 FR 2744, 86 FR 73522). A variety of factors, including inadequate staffing, training, and in some cases regulatory limitations on land uses (*e.g*., agricultural activities) and policy direction, has resulted in ineffective protection of aquatic habitats important to migrating, spawning, or rearing salmon and steelhead. The deficiencies of the current program are particularly acute during large-scale flooding events, such as those associated with El Niño conditions, which can put additional strain on the administration of the CWA Section 401 and Section 404 programs.

The U.S. has a "no net wetland loss" policy under the CWA, though in California the land use regulation of coastal wetlands has been most directly administered under the State of California's federally certified Coastal Zone Management Program and the CCWA. Despite these regulatory programs, modification of the waters of the U.S. (including stream and river courses and coastal wetlands) continue to degrade aquatic habitats utilized by steelhead within the South-Central California Steelhead Recovery Planning Area.

Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)

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 28 commonly applied chemical insecticides, herbicides, and fungicides, which are authorized for use per EPA label criteria.

The following compounds have been found to jeopardize and can modify critical habitat for the South-Central California Coast Steelhead DPS: 2,4-D, Chlorpyrifos, Diazinon, Malathion, Diflubenzuron, Naled, Carbaryl and Carbofuran, Fenbutatin oxide, Propargite, Phosmet, Methomyl, Pendimethalin, Trifluralin, Oryzalin, and Chlorothalonil. All listed West Coast Pacific salmon and steelhead are identified as jeopardized by at least one of the above chemicals; most are identified as being jeopardized by more than one of the chemicals (NMFS 2009, 2010, 2011b, 2012, 2015a, 2017b, 2021b). Pesticides in agricultural runoff has been identified in all south-central California steelhead BPGs as one of the key emergent or ongoing habitat concerns since the 2016 5-year review.

Coastal Zone Management Act (ZMA)

The Coastal Zone Management Act of 1973 (CZMA) is a federal program that provides grant funding to states that adopt a Coastal Zone Management Program (CZMP), which must, at a minimum, incorporate state clean water and air quality laws and regulations pursuant to the CWA and clean air statutes. California's CZMP incorporates state water quality laws, air quality laws, and, the California Environmental Quality Act (CEQA). The CZMA provides basic guidance for environmental stewardship and protection of coastal resources including wetland and fisheries resources and creates a unique opportunity through its “federal consistency” provisions, for states to review and certify that federal actions that affect the coastal zone, regardless of their location, comply with the adopted and federally certified state CZMP.

The California’s CZMP, was approved by NOAA in 1978, and has three components: (1) the California Coastal Commission (CCC) that manages development along the California coast; (2) the San Francisco Bay Conservation and Development Commission (BCDC) that oversees development within San Francisco Bay; and (3) the California Coastal Conservancy (CC) that provides funding for the, purchase of coastal properties, and projects that protect, restore, and enhances coastal resources, and provide public access to the shore. The CCC’s coastal zone generally extends 1,000 yards inland from the mean high tide line. In significant coastal estuarine habitat and recreational areas, it extends inland to the first major ridgeline or 5 miles from the mean high tide line, whichever is less.

California’s Coastal Zone encompasses 14 counties, 3 of which are in the South-Central California Coast Steelhead DPS (Santa Cruz, Monterey, and San Luis Obispo). California’s CZMP uses a variety of planning, permitting, and non-regulatory mechanisms to manage its coastal resources. The CCC implements the CZMP through the issuance of coastal development permits (CDPs), reviewing local governments’ Local Coastal Programs (LCPs), reviewing appeals of locally permitted CDPs, and, under the CZMA’s federal consistency provisions, reviewing projects undertaken by a federal agency, or federally permitted, or federally funded activities (whether to a local or state government).

NMFS’ South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) incorporates recovery actions that recommends the review of applicable County and/or City LCPs and modifications to provide specific regulatory provisions, when appropriate for the protection of all steelhead life-history stages, including adult and juvenile migration, spawning, incubation and rearing (NMFS 2013a: Table 8-1 Recovery Actions Glossary, and Recovery Actions).

The CZMA requires that NOAA periodically review the performance of states with a federally approved CZMP. NOAA’s Office for Coastal Management reviewed the performance of California’s CZMP from January 2009 to June 2018 (NOAA 2019). The review focused on public access, coastal resilience, sea level rise, habitat restoration, sediment management, and LCPs. The evaluation concluded that California’s CZMP has been successfully implementing and enforcing its federally approved coastal management program, adhering to the terms of the federal financial assistance awards and addressing coastal management needs identified in Section 303(2) (A) through (K) of the Coastal Zone Management Act (NOAA 2019), and as a consequence, the risk to the South-Central California Coast Steelhead DPS has been appreciably reduced.

Non-Federal Programs

At the time of listing of West Coast Pacific salmon and steelhead, several non-federal regulatory and planning mechanisms were available to address the conservation of steelhead populations within the South-Central California Coast Steelhead Recovery Planning Area. Some of the more pertinent programs are described below:

Fisheries Restoration Grant Program (FRGP)

In California, the federal PCSRF monies (and other nonfederal derived monies) are administered through the California Department of Fish and Wildlife's Fisheries Restoration Grant Program (FRGP) that was established in 1981 (https://wildlife.ca.gov/Grants/FRGP). The FRGP was initially dependent upon nonfederal derived monies, but in 2013 became wholly reliant on federal PCSRF funds. The California FRGP provides funding for:

- Projects and activities that provide demonstrable and measurable benefits to Pacific anadromous salmonids and their habitat;
- Restoration projects that address factors limiting the productivity of ESA-listed West Coast Pacific anadromous salmonids as specified in approved, interim, or proposed Recovery Plans. This includes projects that are a necessary precursor to implementing the restoration projects;
- Effectiveness monitoring of habitat restoration actions at the watershed or larger scales for ESA-listed anadromous salmonids, or status monitoring projects that directly contribute to population viability assessments; and
- Other projects consistent with but not included in the above, such as outreach, coordination, research, monitoring and assessment projects that can be justified as directly supporting the goals of the program.

Each year the California FRGP solicits proposals for projects that address the goals of the program through its Proposal Solicitation Notice (PSN). Applicants must submit proposals that address a task (or recovery action) in one of the state or federal salmon or steelhead recovery plans. Additionally, a list of priority watersheds and project types are identified in the PSN that help guide the development of project proposals and their evaluation by CDFW in the award granting process (CDFW 2021). CDFW has also used the FRGP PSN as a means of distributing Steelhead Report and Restoration Card (SHRRC) funding. That practice continued until 2020 when the amount of funds available through SHRRC became too small to warrant their inclusion in the PSN solicitation. Between 2015 and 2020, CDFW also included its Forest Land Anadromous Restoration (FLAR) funds in the PSN solicitation for projects on state forestlands that benefitted salmon and steelhead. However, since there are no state forests (only the four U.S. National Forests) within the South-Central California Coast Steelhead Recovery Planning Area, this funding source is not available in south-central California (M. Larson, personal communication).

During the periods 2014-15 and 2020-21 CDFW has distributed over $135 million to fund 388 projects in California through its FRGP PSN. Of this statewide total, approximately $26 million (20%) have gone to fund 53 projects (14% of the total number of funded projects statewide) in the south-central California counties that are within the threatened South-Central California

Coast Steelhead DPS. These funds have made substantial contributions to the remediation of habitat loss or degradation and therefore to the recovery of the South-Central California Coast Steelhead DPS. Table 10 provides the annual amounts of PCSRF and FRGP funds awarded within the south-central California counties within the South-Central California Coast Steelhead Recovery Planning Area, and coast-wide awards that included the 4 south-central California counties.

Table 10. Distribution of Pacific Coast Salmon Restoration Funds/Fisheries Restoration Grant Program within the South-Central California Coast Steelhead DPS: 2014-2021

Year	Santa Cruz County	Monterey County	San Benito County	San Luis Obispo County	Coast-Wide California Coastal Counties
2014-15				$30,368 $222,851	$117,806 $552,745
2015-16			$54,388		$223,833 $450,000
2016-17				$116,016	$473,819
2017-18		$968,568		$1,050,591	$481,925
2018-19	$330,196*	$330,196*	$330,196*	$330,196*	$548,792 $93,962 $157,907 $1,750,000
2019-20			$332,461		
2020-21					$617,589 $388,261
Totals	$330,196	$1,298,764	$717.045	$1,750,022	$5,856,639

* Grant awards shared between multiple South-Central California counties. Individual county totals include shared grant awards between South-Central California counties, but not coast-wide grants in California coastal counties, which are tallied separately. Source: California Department of Fish and Wildlife Fisheries Restoration Grant Program (FRGP) database.

California Coastal Monitoring Program (CMP)

The California Coastal Monitoring Program (CMP), described in Adams *et al.* (2011), is based on the viable salmonid population framework of McElhany *et al*. (2000) to assess salmonid viability in terms of the four population metrics: abundance, productivity, spatial structure, and diversity. The California CMP divides the Coastal Zone of California into a North Coast Area and South Coast Area based on differences in species composition, levels of abundance, distribution patterns, and habitat differences that require differing monitoring approaches.[20] California CMP data can include adult estimates that use redd count surveys of stream reaches and a statistically-valid sampling design expanded to adult estimates based on spawner/redd ratios, as well as redd surveys and estimates that are not expanded to adult estimates (*i.e*., where no spawner/redd ratio estimates are available), and weir counts.

The longer time series available in the northern coastal monitoring area, since the California CMP has been implemented, has improved NMFS' ability to assess status and trends for a number of salmon and steelhead populations. However, spatial coverage has been lacking in the southern coastal monitoring area and remains highly patchy in other geographic areas. Intermittent implementation and methodological issues also continues to hinder assessment of a number of populations. The California CMP nonetheless provides a better basis for informing NMFS' assessments and 5-year reviews and is expected to improve as these time series become longer and more widely applied.

In the original formulation by Adams *et al*. (2011), monitoring methods for the North Coast Area were considerably more developed than for the South Coast Area. Key impediments to monitoring in the South Coast Area stemmed from: (1) the episodic flow regime characteristic of the area's river systems; (2) the sparse distribution or "detectability" of adult steelhead; and (3) the need to distinguish rare anadromous forms from the more common resident form of *O. mykiss*; *see* Pipal *et al.* (2010b, 2010a, 2012), Tasi and Carmody (2017).

An updated strategy for monitoring steelhead and the resident conspecific form of *O. mykis*s has been developed to address these issues as well as a number of related methodological and analytical issues for the South Coast Area (Boughton *et al.* 2022b). The modifications to Adams *et al*. (2011) include: (1) stratifying sampling by "targets of estimation" identified in NMFS' recovery plans for the South-Central/Southern California Recovery Domain; (2) conducting electrofishing surveys instead of snorkel surveys during the low-flow season; (3) modifying the sampling frame to include "short reaches" for low-flow survey; and, (4) incorporating an additional stage of sampling in the low-flow season to identify the proportion of habitat that is unsuitable due to lack of surface flow (Boughton *et al*. 2022b).

Added flexibility for abundance monitoring, deploying redd surveys or counting stations, (depending on which is best suited to field conditions of a given BPG) is proposed; also, proposed is additional flexibility with respect to methods used in Life Cycle Monitoring stations, where smolt production, redd surveys, and adult counts are made in combination. Guidance on how the sampling framework can support a broader vision of combining data with life-cycle models, to learn how to establish productive fish stocks in the coming years is also provided.

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[20] The North Coast Area extends from the Smith River in Del Norte County, south to Aptos Creek in Santa Cruz County. The South Coast Area extends from the Pajaro River in Monterey County, south to the Tijuana River in San Diego County.

Finally, explicit indicators for diversity monitoring, including anadromous fraction, which is a key need for monitoring viability and refining viability criteria for steelhead populations in the South Coast Area, are identified in the updated monitoring strategy (Boughton *et al*. 2022b).

Implementation of the updated monitoring strategy will require additional methodological development, especially for refinement of the design for counting stations. However, these modifications should provide a more efficient, more information-rich monitoring scheme that is practical to implement, and ensure a closer integration of the California CMP with NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a). Long-term dedicated resources to support California's anadromous salmonid monitoring program and address critical scientific questions are critical to the effective implementation of the updated California CMP. Implementation of the updated California CMP steelhead monitoring strategy for the Southern Coastal Area will contribute to reducing risk to the South-Central California Coast Steelhead DPS by providing more comprehensive and fine-scale information on the status of individual steelhead populations (both adults and juveniles), and therefore more focused implementation of recovery actions identified in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a).

California State Water Resources Control Board (SWRCB)

California's State Water Resources Control Board (SWRCB) is the principal agency with responsibility for managing California water resources, including the protection of instream beneficial uses, through the protection of instream flows and water quality. The SWRCB's water-rights permitting system contains provisions (including public trust provisions) for the protection of instream aquatic resources, including salmon and steelhead. However, the permitting system does not provide an explicit regulatory mechanism in the South-Central California Coast Steelhead Recovery Planning Area to implement CDFW's Code Section 5937, which requires the owner or operator of a dam to protect fish populations below impoundments.[21] CDFW's related Code Section 1600 Lake or Streambed Alteration Agreements program is the principal mechanism through which CDFW provides protection of riparian and aquatic habitats, including instream flows. However, inadequate funding, staffing levels, training and administrative support have led to inconsistent implementation of this program, resulting in inadequate protection of riparian and aquatic habitats important to steelhead migration, spawning and rearing; *see* Grantham and Moyle (2014), Hall and Perdigao (2021).

Additionally, the SWRCB generally lacks the oversight and regulatory authority over groundwater development comparable to surface water developments for out-of-stream beneficial uses. The passage of the SGMA in 2014 partially addresses this inadequacy in some, but not all, groundwater basins; further, SGMA is administered by the California Department of

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[21]California Fish and Game Code §5933 provides for the construction of fishways over new dams or the enlargement of existing dams in connection with applications filed with the California Department of Water Resources.

Water Resources, which lacks a public hearing process (and related administrative procedures) comparable to the SWRCBs and RWQCBs.

NMFS participates in the SWRCB's water rights/protest. For example, the water right permit issued by the SWRCB to California American Water Company incorporates significant operational changes, as well as studies, expressly to improve steelhead habitat conditions in the Carmel River. These and other actions taken by the SWRCB to address impacts of water developments on native aquatic resources have appreciably reduced the risk to the South-Central California Coast Steelhead DPS (SWRCB 2019).

California Water Action Plan (CWAP)

The California Water Action Plan (CWAP)[22] was issued in 2014 and identifies 10 priority actions that guide the state's effort to create more resilient, reliable water systems and to restore critical ecosystems. Action 4 specifically addresses the instream flow needs of declining populations of salmonids, including salmon and steelhead, affirming that, "the State Water Resources Control Board and the Department of Fish and Wildlife will implement a suite of individual and coordinated administrative efforts to enhance flows statewide in at least 5 stream systems that support critical habitat for anadromous fish." As part of implementing Action 4, CDFW's Instream Flow Program is developing flow criteria in 5 priority streams throughout the state that support critical habitat for threatened and endangered salmon and steelhead. The CDFW is using the California Environmental Flows Framework (CEFF) to identify ecologically significant flows for rivers and streams in California. The CEFF utilizes historical flow records and site-specific instream habitat analysis to quantify ecologically relevant flow characteristics (flow magnitude, frequency, duration, timing, and rate of change at discrete stream reaches). The identified flow characteristics are intended to assist CDFW and SWRCB in identifying flow patterns for 5 identified "functional flow components" (fall pulse flow, wet-season baseflow, wet-season peak flow, spring recession flows, and dry-season baseflow) that influence habitat suitability for various life-stages of salmon and steelhead. However, the CEFF does not specifically consider groundwater-surface flow interactions, or adequately address essential habitat forming or migratory attraction flows; *see*, for example, Cowan *et al.* (2021), Maher *et al.* (2021). The resulting ecological flow recommendations will be used in water management, planning, and decision-making processes, which may include submitted recommendations to the SWRCB pursuant to Public Resources Code Sections 10000-10005.

Sustainable Groundwater Management Act (SGMA)

Groundwater is a major source of California's water for agricultural, municipal and industrial uses, providing between 40 to 60 percent of the state's out-of-stream water needs (Hanak *et al*. 2011, Chappelle *et al*, 2017). Groundwater also supports a wide variety of groundwater dependent ecosystems, including spawning and rearing habitats for listed salmon and steelhead

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[22] https://wildlife.ca.gov/Conservation/Watersheds/Instream-Flow/Action-Plan.

such as the federally listed threatened South-Central California Coast Steelhead DPS. Many of the Central Coast groundwater basins have been over-drafted and are at risk of being degraded or lost as a water source to support out-of-stream and instream beneficial uses (Hanak *et al*. 2011, Larsen and Woelfle-Erskine 2018, California Department of Water Resources 2020); *see* also, Jasechko and Perrone (2021), Jasechko *et al*. (2021).

SGMA was signed into law in January 2015, during the height of the state's recent historic drought, to address groundwater management issues. SGMA requires groundwater basins with currently unsustainable groundwater usage to form local Groundwater Sustainability Agencies (GSA) by 2017. GSAs must develop a Groundwater Sustainability Plan (GSP) by 2022 that achieves sustainable groundwater conditions no later than 2042. Sustainability under SGMA is defined as avoiding 6 "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 salmon and steelhead, NMFS has actively participated as a stakeholder in many GSP development processes throughout the state, advising GSAs how they should consider streamflow depletion impacts to salmon and steelhead habitat. A provision in SGMA legislation allows GSAs to avoid addressing undesirable results occurring prior to January 1, 2015; however, some GSAs are interpreting this language as allowing streamflow depletion rates associated with the 2014 summer low stream flow conditions as an appropriate management objective. Because 2014 was the third year in the driest 4-year period in California's recorded history, NMFS has expressed concern that streamflow depletion thresholds associated with 2014 groundwater levels are inappropriate and likely inadequate to protect ESA-listed salmon and steelhead or their habitat (Lund *et al*. 2018, Mount *et al.* 2018).

NMFS is currently coordinating with CDFW, other state regulatory agencies, and interested stakeholders to ensure that appropriate groundwater depletion thresholds are included in all applicable GSPs that will provide surface flow essential to support for all salmon and steelhead life-history stages, including adult and juvenile migration, spawning, incubation, and rearing. The SGMA has the potential to reduce the risk to a number of Core 1 and 2 steelhead recovery populations within the South-Central California Coast Steelhead DPS. However, the GSPs submitted to date to the California Department of Water Resources for certification have not contained adequate provisions to ensure the protection of steelhead habitats (particularly rearing habitat) from the impacts of groundwater extractions within the South-Central California Coast Steelhead DPS.

Medicinal and Adult-Use Cannabis Regulation and Safety Act

The legalization of the medical use of cannabis in California in 1996, and for recreational use in 2016, has resulted in significant expansion of cannabis cultivation operations and related land-use and water use developments. These new developments have and will continue to have a significant impact on habitats, including habitats for salmon and steelhead, particularly through the withdrawal of water from spawning and rearing habitats for irrigation of cannabis crops. In response to the expanded legalization of cannabis use, the California legislature in 2015 established the first statewide regulatory program for medical cannabis, 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 in 2017. This legislation established several statewide permitting programs for the cannabis industry, three of which pertain specifically to minimizing environmental impacts arising from outdoor cannabis cultivation. CDFW, SWRCB, and RWQCBs administer these programs.

CDFW is responsible for ensuring cannabis cultivation does not adversely impact fish and wildlife resources (Thompson *et al*. 2014, Bauer *et al*. 2015). The principal regulatory mechanism used by CDFW is CDFW's Lake and Streambed Alteration Agreement process as well as the enforcement of other applicable Fish and Game Code and California Penal Code provisions. The SWRCB and RWQCBs also regulate various aspects of cannabis cultivation related to water diversion and pollutant discharge. The SWRCB's Cannabis Cultivation Policy addresses water quality impacts through various regulations administered by the RWQCBs, including those setting riparian setback and slope limitations, road development stream crossing requirements, and fertilizer and pesticide application and management protocols (SWRCB 2019). The SWRCB 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 (diversions are not permitted between April 1 and October 31), and mandatory bypass flow requirements at each diversion point.

The SWRCB, RWQCB, and CDFW regulatory and permitting programs are intended to provide a comprehensive approach to minimizing cannabis cultivation impacts to *surface* water quality and quantity, including those affecting salmon and steelhead. However, most cannabis cultivators seeking permits from CDFW and SWRCB frequently propose using groundwater pumping as their water source, thus avoiding the seasonal and bypass flow requirements stipulated for surface water diversions by the SWRCB. Some of these wells are in close proximity to streams and rivers, since shallow groundwater depths decrease well drilling costs. These wells may deplete hydraulically connected streamflow, significantly impairing salmon and steelhead instream habitat, especially during summer months when flows are lowest and irrigation demand highest. This important groundwater-surface water relationship largely goes unrecognized and un-analyzed during local and state permitting processes. Another factor that limits the California's environmental protection efforts is the number of illegal/unregulated cultivation operations. Much of this activity occurs on U.S. Forest Service (USFS) lands, including the Los Padres National Forest, which fall within federal jurisdiction (NMFS 2013a, Koch *et al*. 2016, and Rose *et al*. 2016, Klose 2018). It is illegal to grow cannabis on federal lands and the USFS law enforcement officers perform periodic aerial surveys to identify and determine the extent of the cannabis cultivation. Removing unregulated cannabis operations and increasing overall industry oversight through MAUCRSA will be required to realize appreciable improvements in instream habitat quality for steelhead and other native aquatic resources.

Listing Factor D Inadequacy of Regulatory Mechanisms: Conclusion

Various Federal, state, county, and city regulatory mechanisms are in place to reduce habitat loss and degradation caused by human use and water development and harvest impacts. New information available since NMFS' 2016 5-year review indicates that the effectiveness of a number of regulatory mechanisms has improved though they still do not adequately address steelhead habitat impacts from land use practices and water developments.

NMFS continues to participate in the Public Trust/Water Right hearings being held by the California SWRCB. NMFS has also conducted both formal and informal Section 7 consultations under the ESA with federal agencies throughout the South-Central California Coast Steelhead DPS that authorize, fund, or carry out, projects such as flood protection, road construction, water diversion, bridge replacements, and gravel mining operations. These consultations have reduced the impacts of these activities on threatened steelhead in the South-Central California Coast Steelhead DPS.

Both the listing of the South-Central California Coast Steelhead DPS as threatened and NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) have also served to inform the preparation of environmental documents under both the National Environmental Policy Act (NEPA) and the state of California's Environmental Quality Act (CEQA). These regulatory mechanisms provide the basic environmental information that informs a majority of land use and water development planning and regulatory decisions at the federal, state, and local levels. Additionally, the application of the ESA's Sections 7 and 10 has substantially enhanced the regulatory oversight of projects affecting federally listed steelhead or designated critical habitat within the South-Central California Coast Steelhead DPS. Significantly, the passage of SGMA has provided a new regulatory mechanism for managing groundwater resources that have been identified as a major issue in the restoration of core recovery populations within in the South-Central California Coast Steelhead DPS.

Federal and state regulatory programs have not been fundamentally altered in the past 5 years (with the notable exception of the passage of SGMA) and as a consequence the threats to steelhead and its habitat from the inadequacies of regulatory mechanisms has remained essentially unchanged since NMFS' 2016 5-year review (Williams *et al.* 2016). Based on the fishery investigations and habitat improvements noted above, we conclude that the risk to the species' persistence has decreased slightly. However, there remain a number of concerns regarding existing regulatory mechanisms, including:

- NFIP regulation of development within flood-prone areas, including the designated flood way and 100-year floodplain, in anadromous watersheds;
- USACOE 404 regulation and administration of permits for the dredging or filling of the

waters of the U.S that affect anadromous watersheds;

- FERC regulation and administration of licenses of hydropower facilities that affect anadromous watersheds;
- USFS and Cal Fire application of fire retardants, and other fire suppression methods such as fire breaks, in anadromous watersheds;
- California Department of Pesticide Regulation and U.S. Department of Agriculture regulation of pesticides use within anadromous watersheds;
- SWRCB, RWQCB, and CDFW implementation of the Medical Marijuana Regulation and Safety Act within anadromous watersheds;
- SWRCB and RWQCB regulation of point and non-point source waste discharges (NPDES and TMDL standards) within anadromous watersheds;
- DWR implementation of SGMA; and
- CDFW implementation of Fish and Game Code Sections 5933 (fish passage around dams), 5937 (passage of water for fish below dams), and 1601-1604 (alteration of stream or lakes) within anadromous watersheds.

See the discussion above regarding individual “Federal Programs” and “Non-Federal Programs.”

Listing Factor E: Other Natural or Man-Made Factors Affecting the Species’ Continued Existence

This listing factor encompasses three distinct threats to the species identified at the time of listing: (1) environmental variability, including projected long-term climate change (and related drought and wildfires); (2) introduction of non-native species into coastal watersheds; and (3) recreational fishing stocking programs.

Recent information about environmental variability (*e.g*., prolonged droughts, intensive cyclonic storms triggering debris flows), including the effects of ocean conditions on the survival and growth of steelhead populations, and increases in wildfire occurrence and severity, indicate that the threat from “environmental variability” can be expected to increase (Staley *et al*. 2020).

Non-native invasive aquatic species is an ongoing issue in many of the coastal watersheds of south-central California (combined drought conditions and re-introductions) that continue to degrade freshwater habitat conditions for rearing juvenile steelhead, as well as other native fish and amphibian species.

Stocking of non-native hatchery reared *O. mykiss* in anadromous waters has ceased, and triploid (sterile) fish are used in current stocking programs. However, the legacy effects of past stocking of non-native hatchery reared *O. mykiss* appear to persist, particularly in the southernmost watersheds of the South-Central California Coast Steelhead Recovery Planning Area, where the natural influx of the anadromous form is more restricted (both by physical fish passage barriers and limited hydrologic connectivity between the upstream habitats and the ocean). See discussion above under "Listing Factor B, Harvest, and below under "Recreational Fish Stocking Programs."

Environmental Variability

Variability in natural environmental conditions has both masked and exacerbated the problems associated with degraded and altered riverine, estuarine, and marine habitats. Floods and drought conditions have periodically reduced naturally limited steelhead migration, spawning, and rearing, and migration habitats. Furthermore, El Niño/La Niña Southern Oscillation events and periods of unfavorable climate-related ocean conditions have resulted in significant fluctuations in returning spawning run-sizes, and can threaten the survival of steelhead populations already reduced to low abundance levels due to the loss and degradation of freshwater and estuarine habitats. However, periods of favorable ocean productivity and high marine survival can temporarily offset poor habitat conditions elsewhere and result in dramatic increases in population abundance and productivity by increasing the size and correlated fecundity of sexually mature returning steelhead; see Hertz and Trudel (2014), Stachura *et al*. (2014).

Overall, the pattern of these threats have remained essentially unchanged since the NMFS' 2016 5-year review (Williams *et al.* 2016, Capelli 2016b), though the magnitude of the threats posed to the continued existence of the species from environmental variability are likely to be exacerbated in the future. See the discussion below on "Climate Change."

Invasive Species

The introduction of non-native fishes, amphibians, crustaceans, and other aquatic species has a long history in California with significant impacts on native species, including south-central California steelhead populations (Shebley 1917, Gamradt and Kats 1996, Dill and Cordone 1997, Simon and Townsend 2003, Kats and Ferrer 2003, Pister 2001, Dunham *et al.* 2004, Francis and Chadwick 2012). Non-native isopods, including the New Zealand mudsnails (*Potamopyrgus antipodarum*) have become widespread in south-central California (Bennett, *et al.* 2015, Benson, *et al*. 2021, Rundio and Lindley 2021). A number of non-native plant species have also become established within the South-Central California Coast Steelhead DPS. One of the most pervasive is the giant reed (*Arundo donax*), which has infested some of the larger watersheds (*e.g.*, Pajaro River and Salina River). *A. donax* can establish large monoclonal communities in riparian corridors and thus have a significant effect on stream habitat: displacing native instream and riparian vegetation, reducing water velocities, reducing base flows, and facilitating wildfires in riparian areas (Swanson 1981, Faber *et al.* 1989, Brock *et al.* 1997, Herrera and Dudley 2003, Quinn and Holt 2008, Coffman *et al.* 2010, Bendix and Commons 2017). Another invasive plant species, Salt Cedar (*Tamarix ramosissima*) has invaded a number of south-central California watersheds. As with *A. donax*, *T. ramosissima* can establish large monoclonal communities in riparian corridors and thus have a significant effect on stream habitat: displacing native instream and riparian vegetation, reducing water velocities, and reducing base flows (Tomaso 1998, Glenn and Nagler 2005, Shafroth, *et al*. 2005, Shafroth and Briggs 2008); *see* also, Stover *et al*. (2018).

The natural distribution of North American beavers (*Castor canadensis*) in California is a subject of considerable interest to the management of native anadromous fishes (Hensley 1946, The Occidental Arts and Ecology Center Water Institute 2013, Lanman *et al*. 2013, Richmond *et al*. 2021). The introduction of *C. canadensis* into a number of the larger river systems in south-central California has resulted in significant modifications to stream habitats that can adversely affect *O. mykiss* (*e.g*., Salinas River). In south-central California, the creation of beaver ponds can have negative effects on native *O. mykiss* (NMFS 2016; D. Boughton, personal communication; S. Cooper, personal communication). These include, but are not limited to: warming stream temperature during the low flow season; impeding the movement of rearing juveniles; creating habitat that favors non-native aquatic species that prey upon or compete for living space of rearing juvenile *O. mykiss*; and facilitating the spread of invasive riparian plant species (Douglas 1995, Naiman *et al*. 1988, Muller-Schwarze, *et al.* 2003, Simon and Townsend 2003, Riley *et al*. 2005, Rossell *et al*. 2005, Gibson and Olden 2014, Law *et al*. 2014); for a recent review of the impacts of non-indigenous *C. canadensis* on the southernmost watersheds in California, *see* also, Richmond *et al*. 2021).

Recreational Fishing Stocking Programs

Steelhead and their related resident forms of *O. mykiss* have supported an important recreational fishery throughout their natural range in south-central California. See discussion of "Harvest Effects" above in "Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes". Recreational angling has been supplemented by a stocking program based on a series of production hatcheries constructed and operated by the California Department of Fish and Wildlife (Shebley 1917, 1922, Butler 1965, Leitritz 1970, Epifanio 2000, Lentz and Clifford 2014), and as well as federal agencies (Halverson 2008). These programs have been pursued since the late1890s, and were expanded considerably during the Progressive Era with the development of the National Forests in California, the expansion of leisure time, and the end of World War II when the return of American troops from abroad put additional angling pressure on native fish populations (Halverson 2008, Lentz and Clifford 2014); *see* also, Spence (2019).

While the stocking of non-native hatchery-reared *O. mykiss* in anadromous waters has ceased, and triploid (sterile) fish are used in current stocking programs, fish stocked upstream of dams can nevertheless escape into anadromous waters which continue to be dominated by progeny of native anadromous *O. mykiss* (Garza and Clemento 2008, Clemento *et al*. 2009). It is unclear how much the historic stocking of hatchery-reared *O. mykiss* from various hatchery programs has influenced the ratio of the AA, AR, and RR genotypes of the current populations of *O. mykiss* (Garza and Clemento 2008, Clemento *et al.* 2009, Garza *et al*. 2014; D. Pearse, personal communication). See discussion in "New Research Relevant to Population-Level Viability Criteria."

Because the stocked fish originated from many different strains of *O. mykiss* and hatcheries over the years, the degree of this influence on the anadromous behavior of the South-Central California Coast Steelhead DPS is currently unknown. Pearse *et al.* (2014, 2019) have included various hatchery trout strains in different studies and they show considerable variability in the frequency of the Omy5 A and R haplotypes. For example, Pearse *et al*. (2014) includes three hatchery *O. mykiss* strains with Omy5 haplotype a ranging in populations from 0 – 62 percent. There is also considerable variability in the linkage among genetic markers within the Omy5 inversion; *see*, for example, Pearse and Garza (2015, Table 1) and Leitwein e*t al*. (2017, Figure 5). Collecting genetic material and analyzing the migration-associated region of the Omy5 chromosome may, however, throw additional light on how the native O. *mykiss* populations (whether anadromous or resident) have been modified with respect to their genetically based anadromy/residency characteristics.

Climate Change

Introduction

Climate plays an important role in Pacific salmon and steelhead (*Oncorhynchus* spp.) habitats at every stage of their life-history. Seasonal variations provide varying water temperature and streamflow regimes that create diverse life-history pathways for different anadromous salmon and steelhead populations of the same and different species. Likewise, climate and weather variations like persistent drought, episodic floods, or persistent marine heatwaves, can alter aquatic habitats and food-webs, which in turn affect individual growth and survival rates in ways that can impact salmon populations at local to regional scales. See Figure 23.

Salmon and steelhead have adapted to a wide variety of climatic conditions in the past, and thus could theoretically survive substantial climate change at the species level in the *absence* of other anthropogenic stressors. However, accelerated climatic changes has the potential to affect salmonid abundance, productivity, spatial structure, and diversity through direct and indirect impacts at all life-stages (Levin 2003, Lindley *et al*. 2007, Independent Scientific Advisory Board 2007, Crozier *et al*. 2008, Crozier and Zabel 2010, Atcheson *et al*. 2012, Moyle *et al.,* 2013, Wainwright and Weitkamp 2013, Wade *et al*. 2013, Walters *et al*, 2013, Shelton *et al*. 2020, Gudmundsson *et al*. 2021); *see* also, Beamish *et al.* (2010), McClure *et al*. (2013), Tohver *et al*. (2014).

The period from 2013–2022 has been exceptional for its high frequency and magnitude of West Coast drought and terrestrial heat, widespread and severe wildfire, and record-setting marine heatwaves in the California Current Large Marine Ecosystem and broader northeast Pacific Ocean. Climate extremes from 2013–2022 have contributed to extreme bottlenecks in Pacific salmon and steelhead survival rates for multiple Pacific salmon and steelhead populations and subsequent declines in abundance for many ESUs and DPSs.

Currently, the adaptive ability of the threatened and endangered salmon and steelhead ESUs and DPSs is depressed due to reductions in population size, habitat quantity and diversity, and loss of behavioral and genetic variation. Without these natural sources of resilience, systematic changes in local and regional climatic conditions due to anthropogenic global climate change will likely reduce long-term viability and sustainability of populations in many salmon and steelhead ESUs/DPSs, including the South-Central California Coast Steelhead DPS. Adapting to climate change may eventually involve changes in multiple life-history traits and/or local distribution, and some populations or life-history variants might be lost. Importantly, the character and magnitude of these effects will vary within and among salmon and steelhead ESUs/DPSs. Figure 23 depicts for a conceptual model of factors (*e.g.*, climate, urbanization, forest cover, stream flow, upwelling, harvest, etc.) affecting life-history stages of Pacific salmon and steelhead.

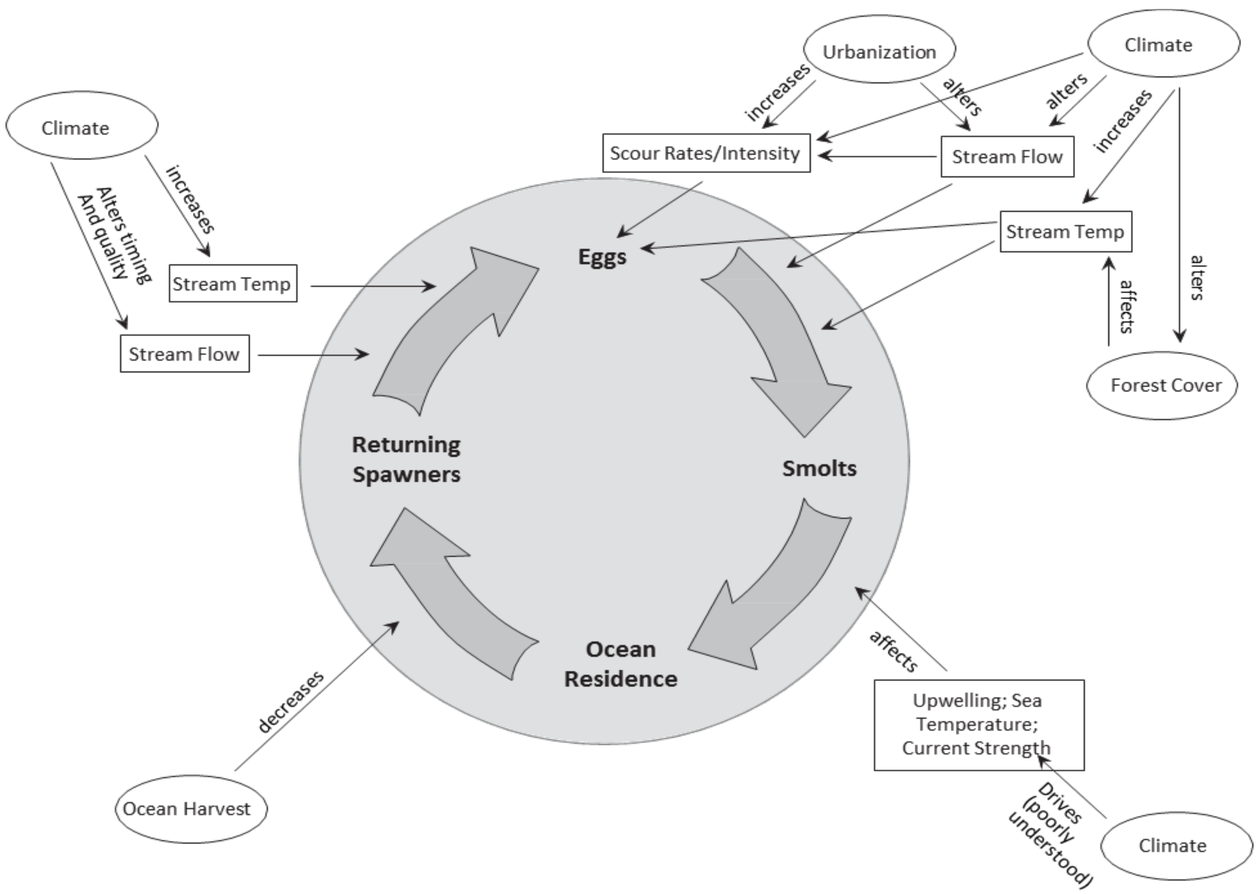


Figure 23. Conceptual model of factors affecting life-stages of Pacific Salmon and Steelhead.

The current status of listed Pacific salmon and steelhead populations is influenced by numerous factors, including human activities (*e.g.*, fishing mortality, habitat restoration and degradation, hatchery production), and natural variation in both freshwater and marine environments. The most recent increasing trends in the numbers of natural spawners observed in some ESUs and DPSs partially reflect favorable environmental conditions in marine waters of the northern California Current and in freshwater habitats in recent years. It is well established that ocean conditions during the first weeks or months of marine life have a large influence on overall marine survival for anadromous salmonids (Pearcy 1992, Pearcy and McKinnell 2007). Accordingly, a large portion of the short-term variation in population productivity may be due to ocean conditions, which fluctuate at short time scales. For example, marine survival can vary by over an order of magnitude between years (Lindley *et al.* 2009); *see* also, Hertz and Trudel (2014).

At various times, especially in the early 2010s, relatively productive conditions resulted in high freshwater and marine survival rates and subsequent high adult returns for many anadromous salmonid stocks throughout the Pacific Northwest. However, changes in ocean and freshwater conditions that included exceptionally warm ocean temperatures in the Northeast Pacific and over western states for much of 2013-2019, along with an extreme multiyear drought from 2012-2016 in California, led to subsequent declines in abundance in many salmon and steelhead ESUs and DPSs, including the South-Central California Coast Steelhead DPS (Boughton 2022 in SWFSC 2022).

The following sections summarize marine and terrestrial conditions (Mantua et al. 2022 and Boughton 2022 in SWFSC 2022), which provide environmental context for the viability assessment for the South-Central California Coast Steelhead DPS. Of primary interest are the climatic conditions that existed over the past 15-20 years.

Observed Environmental Conditions

Precipitation and surface air temperature - A strong and persistent warming trend and large year-to-year variations in precipitation are among the most notable climate features of the western U.S. in recent decades. For both the Pacific Northwest and California, water year 2015 stands out as the warmest year on record, while water year 2018 is the second warmest year on record for California. Surface air temperatures in water years 2014-2018 in California were, on average, much warmer than the period from 1981-2010. Figure 24 depicts surface air temperatures in California with a general upward trend beginning in 1985, from an average of 58.40^0 F. to c. 16.5^0 F. Figure 25 depicts precipitation in California with wide interannual variations from 1895-2020—from an average of 22.78 inches—from less than 10 inches to over 40 inches.

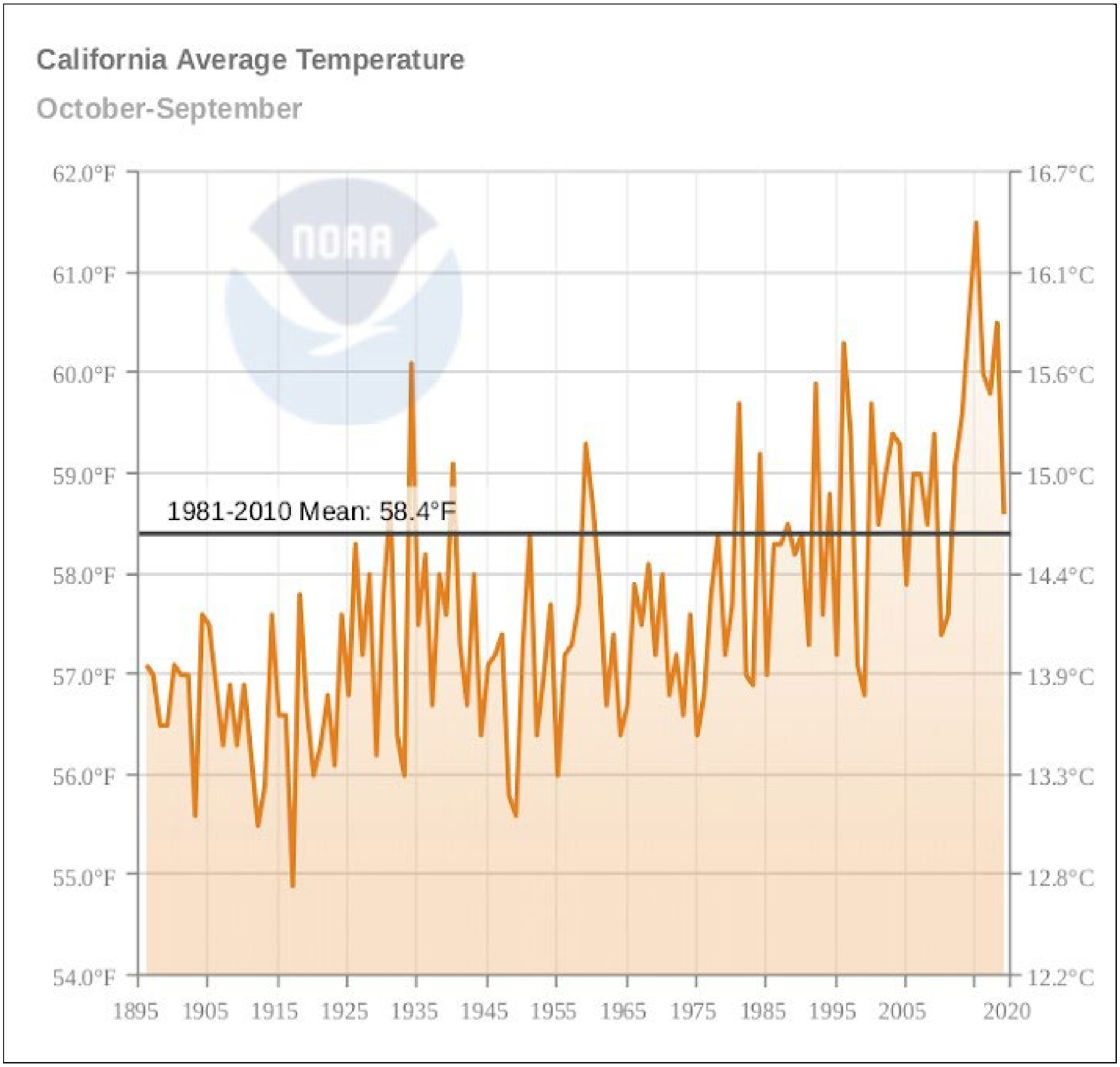


Figure 24. Water year (October-September) surface air temperature for California. The historical average for 1981-2010 is shown with the black horizontal line. The figure shows U.S. Climate Division Data and was created at https://www.ncdc.noaa.gov/cag/regional/time-series.

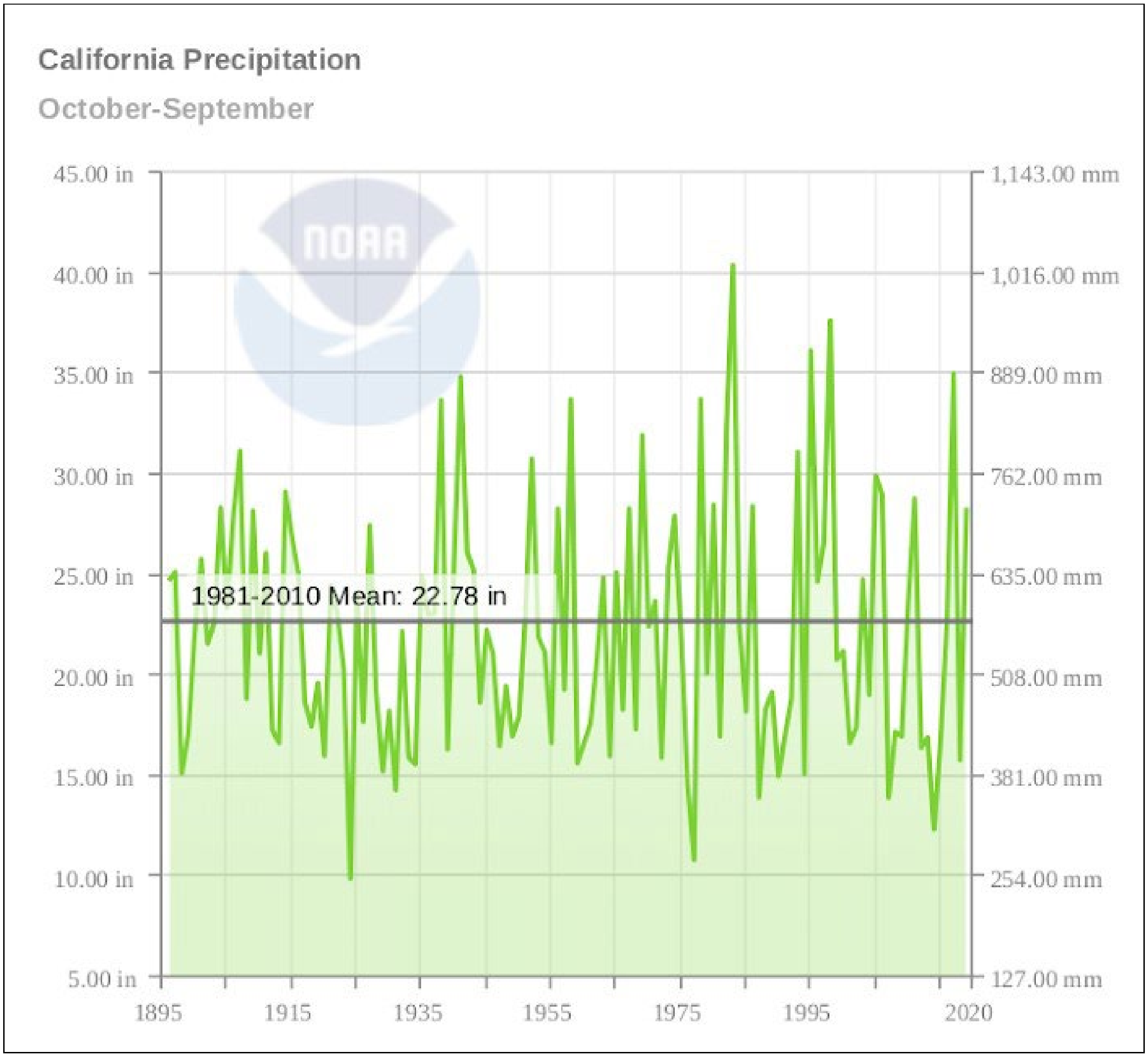


Figure 25. Water year (October-September) precipitation for California. The historical average for 1981-2010 is shown with the black horizontal line. The figure shows U.S. Climate Division Data and was created at https://www.ncdc.noaa.gov/cag/regional/time-series.

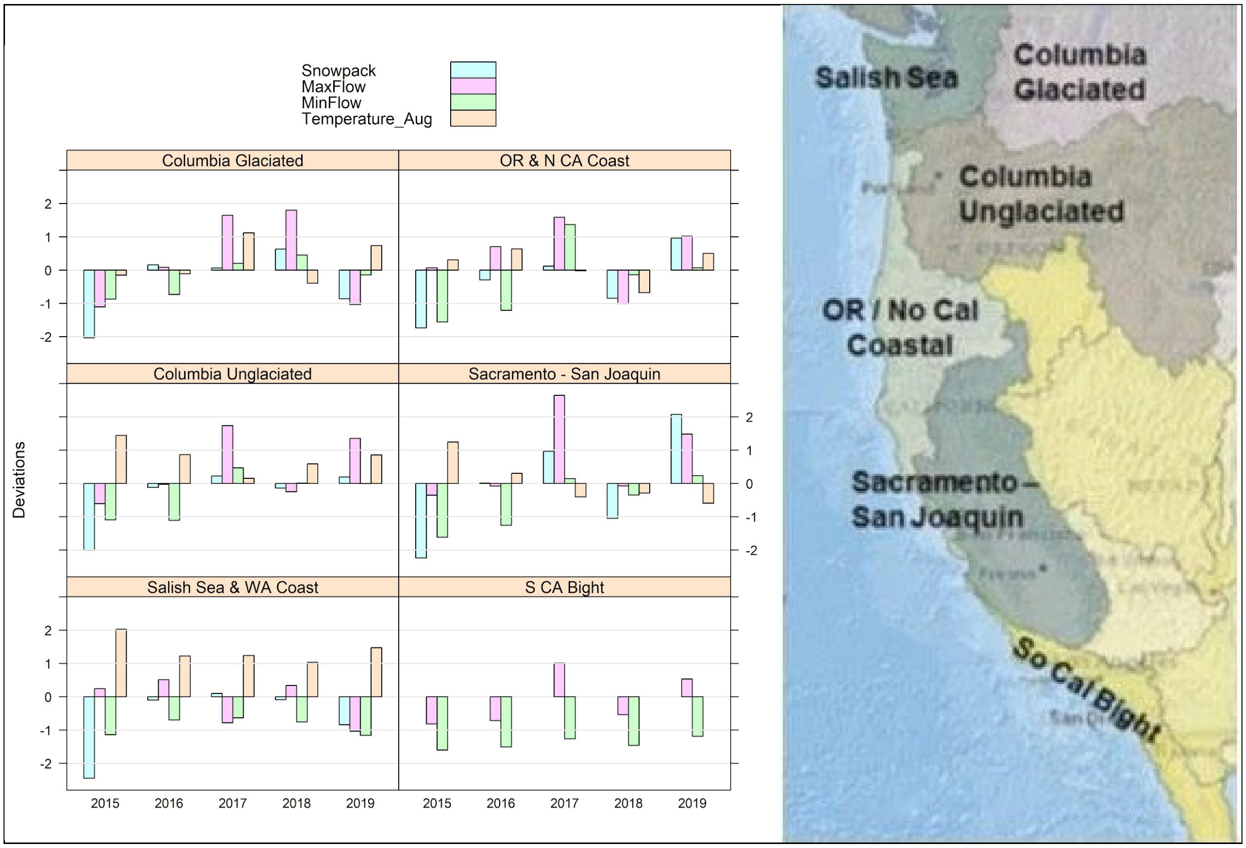
Stream flow – California's multiyear drought of 2012-2016 was especially notable for the persistence and magnitude of above average surface air temperatures, below average precipitation, below average snow pack, and below average streamflow throughout the state. For a detailed discussion of the effects of this drought on the South-Central California Coast Steelhead DPS; *see* Section 2.3 "Updated Information and Current Species' Status."

Annual anomalies from recent past - Over the past century, air temperatures have risen steadily, while precipitation remains highly variable. Warmer temperatures intensify the hydrological cycle within the atmosphere, causing more intense storm events (Warner *et al.* 2015). Projections of climate change in the western U.S. indicate that both of these trends are likely to continue. Summer precipitation is projected to decline, exacerbating low flows and high stream temperatures in the western U.S (U.S. Global Change Research Program 2018).

Winter conditions affect most salmon and steelhead during the egg and early rearing stages, which may be disturbed and relocated during flood events (Salathé *et al*. 2014, Harrison *et al*. 2017). Emigrating smolts typically benefit from higher flows, although the impacts on migrating adults varies across populations. Summer conditions affect juveniles rearing in streams and over-summering adults (*i.e*., kelts) (Beakes *et al.* 2010, Faulkner *et al*. 2019, and Notch *et al*. 2020).

A recent assessment of climate change across NMFS' West Coast Region (Crozier *et al.* 2019) found that by the 2040s, average stream temperatures are likely to increase by over 2 standard deviations across most of the region, and either flooding (southern domains) or loss of snowmelt (northern domains) and was also very likely to change dramatically in most salmon and steelhead ESUs and DPSs. These projected changes are presented within the context of recent conditions (2015-2020) by four metrics (summer stream temperature, low flow, high flow, and snowpack) in terms of standard deviations from the recent historical mean (1998-2014). Although they are *currently* anomalous years, they are likely to represent *average* conditions in the near future.

To facilitate interpretation of salmon and steelhead dynamics within individual ESUs and DPSs, Harvey *et al*. (2018, 2019, and 2020) averaged environmental conditions across many measurement stations within each of 6 ecoregions in NMFS' West Coast Region from the interior Columbia River Basin to the Washington coast to southern California. These results were re-analyzed to consider the 2015-2019 period specifically in relation to the mean and standard deviation of the previous 15 years (1998-2014). Deviations for each year (Y_T) were calculated from the raw value (X_t) as $Y_T = (X_t - X_{mu})/X_{sd}$ for each region, where X_{mu} and X_{sd} were the mean and standard deviation, respectively, over the 1998-2014 period. See Figures 26A and 26B.



A) B)

Figure 26. A) Deviations from the 1998-2014 baseline period in selected ecoregions in the maximum 1-day flow event per year (MaxFlow), the minimum 7-day flow event per year (MinFlow), snowpack on April 1, and mean August stream temperature. B) Map of freshwater ecoregions within which conditions were averaged. (Courtesy of Harvey *et al.* 2019.)

In 2015, the combination of below-average precipitation and record-high surface air temperature brought record-low springtime snowpack to much of the west, leading to what has been called "the western snow drought." Figure 26 depicts the deviation from the 1998-2014 baseline period of 1-day flow, 7-day flow, snowpack and mean August temperature in selected ecoregions (Salish Sea, Columbia Glaciated/Un Glaciated, Oregon/Northern California, Sacramento-San Joaquin, and the Southern California Bight) with the Southern California Bight exhibiting a generally negative stream flow deviation. The diminished snow pack and high surface temperatures combined with low springtime precipitation yielded especially low runoff to western watersheds in spring and early summer 2015. Temperatures returned to near normal in much of Washington and Idaho in August (which is the month shown in Figure 26), but then spiked again in the fall of 2015. Unusually low flows and warm stream temperatures in spring/summer 2015 caused widespread problems for salmon and steelhead and throughout the western United States.

In 2016, minimum flows continued to show long-term drought effects, especially in California and the unglaciated portion of the Columbia River Basin, but other indices were transitioning to more favorable high flows of 2017 in most regions, though not in south-central or southern California.

Two ecoregions stood out in showing strongly anomalous conditions in all 5 years: summer temperatures were above average (>1SD) in the Salish Sea and Washington Coast region, and minimum flows were below average (>1SD) in southern California throughout the period covered by this 5-year review.

Particularly notable climate impacts on salmon and steelhead occurred throughout the 2012-2016 drought in California. Effects of the drought on stream networks accumulated each year rather than reflecting precipitation directly (Deitch *et al*. 2018); *see* also, Williams *et al.* (2015), Jasechko *et al*. (2021). Thus prolonged periods of dewatering occurred for multiple years. The previous drought from 1987-1992 likely had similar but even more prolonged effects. Other studies (Larsen and Woelfle-Erskine 2018) found that juvenile salmonids preferentially select pools with more groundwater inflow, which stabilizes streams during low-flow periods. Thus, drawdown of coastal aquifers would directly affect potential habitat for threatened and endangered salmon and steelhead. For example, during the drought, rearing juveniles moved between coastal lagoons and mainstem Scott Creek to regulate key physiological processes under the prolonged duration (7 months longer than average) of seasonal sandbar closure (Osterback *et al*. 2018).

Ocean Conditions

Surface temperatures in the Northeast Pacific Ocean were notably cooler than average from 1999-2002 and again from 2006-summer 2013, warmer than normal from 2003-2005, and at record high temperatures for much of the period from fall 2013-2019. Figure 27 depicts the monthly sea-surface temperature anomaly of the Northeast Pacific Arc from 1900-2020, showing a pronounced warming trend beginning in in 2015/16.

For the California Current region, sea surface temperatures reached record high levels from 2014-2016, with 2015 being the single warmest year in the historical record (Jacox *et al*. 2018). The extreme ocean temperatures for the Northeast Pacific Ocean and California Current were associated with a small number of persistent wind and weather patterns, some of which have been related to climate conditions in the tropical Pacific Ocean (Di Lorenzo and Mantua 2016, Jacox *et al*. 2018). Figure 28 presents a schematic depiction of principal Northeast Pacific Ocean currents (Subarctic, Alaska, and California), and areas of coastal downwelling (Alaska/Northern Canada) and upwelling (Canada and California coast).

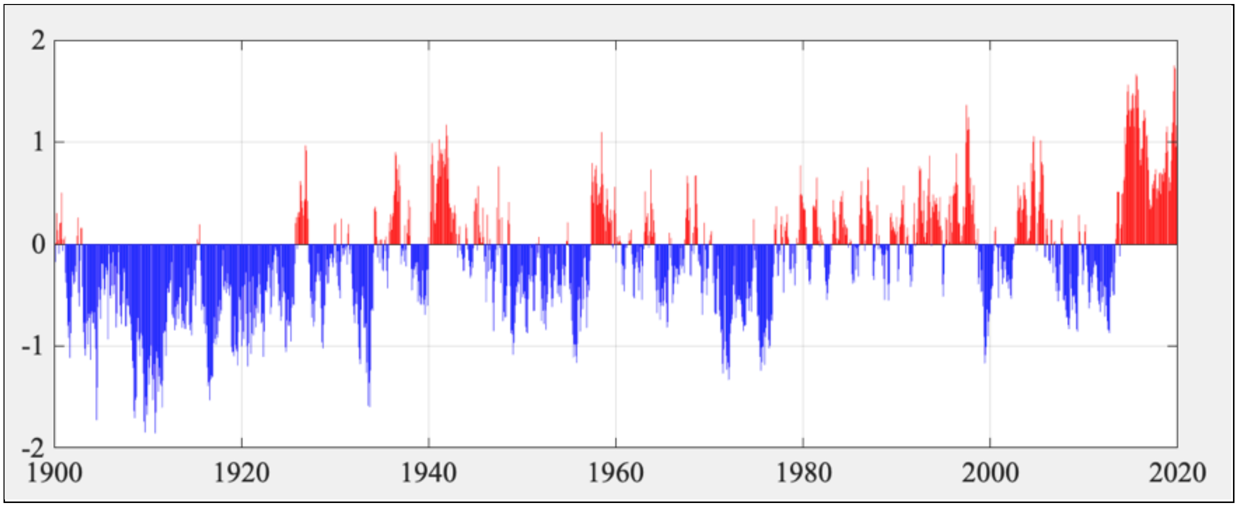


Figure 27. Monthly average sea surface temperature anomaly time series (in Degrees C) for the NE Pacific Arc pattern defined by Johnstone and Mantua (2014).

Biological response to marine conditions since 2014 – A number of reports provide overviews of recent physical and biological conditions in regions of the Northeast Pacific Ocean that West Coast Pacific salmon and steelhead may experience during their marine residence period:

- California Cooperative Oceanic Fisheries' (CalCOFI) State of the California Current (Thompson 2019)
- Integrated Ecosystem Assessment's California Current Ecosystem Status Report (Harvey *et al.* 2020)
- Canadian Department of Fish and Ocean's State of the Physical, Biological and Selected Fishery Resources of Pacific Canadian Marine Ecosystems (Boldt *et al.* 2019, 2020)
- Alaska Fisheries Science Center's Ecosystem Status Reports for the Gulf of Alaska (Zador *et al*. 2019), Eastern Bering Sea (Siddon and Zador 2019), and Aleutian Islands (Zador and Ortiz 2018)
- Southwest Fisheries Science Center Coastal Pelagic Survey reports (Stierhoff *et al.* 2020).

In all cases, the reports show a dramatic biological response at all trophic levels—from primary producers to marine mammals and sea birds—to the marine heat waves that have spread across the Northeast Pacific Ocean since 2013 and continue into 2022. These ecosystem changes have had large effects (both positive and negative) on Pacific salmon and steelhead returns around the Pacific Rim, not just listed species on the West Coast. Brief summaries are provided of the biological trends described by these reports and sources, with an emphasis on findings that are pertinent to salmon and steelhead survival on the West Coast. Unless noted, the information comes from the above report series.

Overall, the Northeast Pacific Ocean heat wave in 2014-2016 had the most drastic impact on marine ecosystems in 2015, with lingering effects into 2016 and 2017. Conditions had somewhat returned to "normal" in 2018, but another marine heat wave in 2019 again set off a series of marine ecosystem changes across the North Pacific Ocean. One reason for lingering effects of ecosystem response is due to biological lags. These lags result from species impacts at larval or juvenile stages, which are typically most sensitive to extreme temperatures or changes in food supply. It is only once these species grow to adult size or recruit into freshwater, or to fisheries, that the impact of the heat wave is apparent. For example, most marine mortality for juvenile salmon and steelhead is thought to occur in the first weeks or months of ocean residence. However, whether marine survival was exceptionally high or low is not known until surviving salmon and steelhead mature and return as adults, 1 to 5 years after ocean entry.

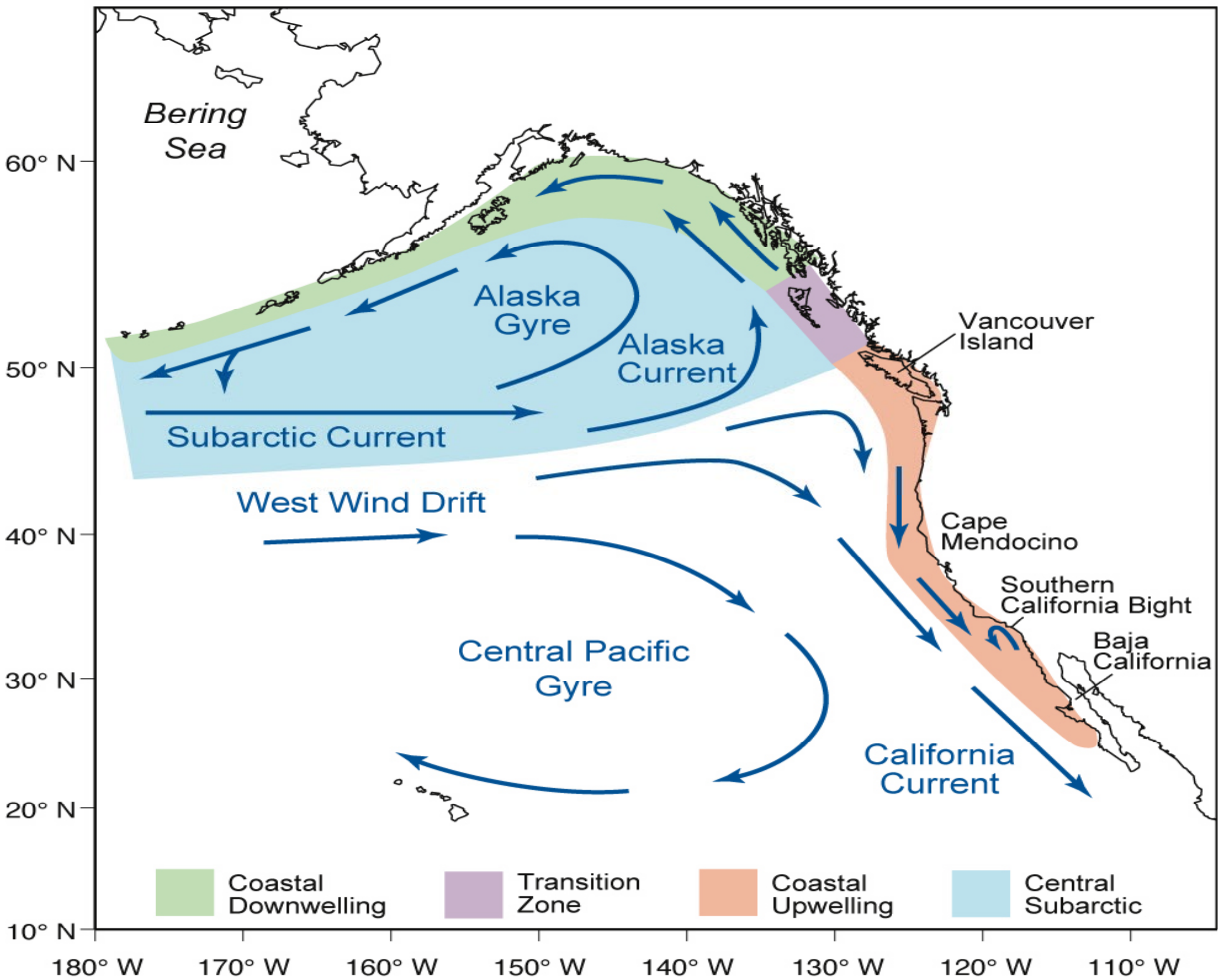


Figure 28. Principal ocean currents in the Northeast Pacific Ocean affecting marine conditions important to Pacific salmon and steelhead. (Courtesy of J. A. Barth, Oregon State University)

Primary production - The largest bloom of the diatom *Pseudo-nitzschia* ever recorded was in 2015 and had perhaps the most dramatic impact to primary producers (McCabe *et al*. 2016, Bates *et al*. 2018). It stretched from southern California to the Aleutian Islands in Alaska, had some of the highest concentrations of cells ever recorded, and was particularly long lasting. *Pseudo-nitzschia* can produce domoic acid, a neurotoxin that causes amnesic shellfish poisoning, which is potentially fatal in mammals (including humans) and seabirds. In marine food webs, filter feeding mollusks (primarily bivalves) and planktivorous fishes such as Pacific sardine and Northern anchovy, consume *Pseudo-nitzschia*, and species that consume contaminated shellfish and fish become sick or die (McCabe *et al*. 2016, Bates *et al*. 2018).

Other notable primary-producer related events include harmful algal bloom of *Noctilua scintillans* and *Heterosigma akashiwo* in the Salish Sea (the Strait of Georgia and Puget Sound) in 2018 after a three-year absence. There were also more harmful algal blooms in 2018 than the previous 3 years in the Strait of Georgia. In the Gulf of Alaska, phytoplankton blooms were earlier and in higher concentrations in 2017-18 relative to warm years of 2014-2016. Surface nutrient concentrations were some of the lowest on record in 2019 across the Gulf of Alaska, which, paired with elevated water temperatures, affected the offshore phytoplankton community, oceanic food webs, as well as oxygen levels and biogeochemistry.

Lower trophic levels: copepods, krill, jellyfish, and pyrosomes - Throughout most of the Northeast Pacific Ocean, the marine heat wave had profound effects on the animals at the base of the food web, which supports ocean maturing salmon and steelhead. Summer copepod communities are normally dominated by cold water (=lipid rich) species, but during the heat wave northern species were largely or completely absent and warm water (=lipid poor) species dominated. Not only were southern species abundant, but novel communities were observed in many areas. On the Newport Hydrographic Line (44.6° N), for example, 14 species of copepods that had never been observed were documented, which originated both offshore and from southern waters (Peterson *et al*. 2017); *see* also, Pearcy (2002). Other changes on the Newport line during the initial heat wave included reduced biomass of copepods and krill, and high abundances of gelatinous organisms such as larvaceans and doliolids (both types of pelagic tunicates). Similar abrupt changes in copepods, krill and gelatinous organisms were observed from southern California to the Gulf of Alaska. In general, most copepod and krill communities had returned to more “normal” conditions in 2018.

Finally, 2017 could be considered the Year-of-the-Pyrosome in the Northeast Pacific, because of the enormous biomass of the pelagic colonial tunicate, *Pyrosoma atlanticum*, present throughout the region (Brodeur *et al.* 2019). Pyrosomes are common in warm open ocean waters throughout the tropics, but are rare north of southern California. Starting in 2014 and 2015, their abundance greatly increased in California waters, and in 2015, they were observed in offshore waters in southern Oregon. In winter 2016, their population exploded and they were everywhere including close to shore in immense quantities: from southern California to northern Gulf of Alaska at densities of up to 200,000 kg/km^3.

The ecosystem effects of the Pyrosome explosion are unknown but are expected to be large due to their extremely large biomass and widespread distribution. Pyrosomes have low nutrient content, making them a low quality, high fiber prey. Despite this, they were observed in the diets of dozens of species from sea urchins and other demersal invertebrates to rockfishes and other commercial fishes, juvenile and adult Pacific anadromous salmonids to fin whales (Brodeur *et al.* 2018); *see* also, Wing (2006). In spring of 2018, they were still present in large quantities off the Oregon coast but effectively absent by fall 2018, but still present off California in 2019.

Forage fish and squid - Like lower trophic levels, the abundance and species composition of forage fish and squid were highly variable from 2014-2019. One species that expanded its range and abundance is the California market squid, *Doryteuthis opalescens*.

Other species that have increased in recent years in the California Current include Pacific pompano (*Peprilus simillimus*), juvenile rockfish (*Sebastes* spp.), adult sardine (*Sardinops sagax*) and anchovy (*Engraulis mordax*), some species of lanternfishes (Myctophidae), and both Pacific jack (*Trachurus symmetricus*) and Pacific chub mackerel (*Scomber japonicus*). Species with marked declines include hake (*Merluccius productus*), juvenile sardine and anchovy, Pacific herring (*Clupea pallasii*), lampfish, and juvenile salmon (especially in 2017 in the Northern California Current). Juvenile rockfish were abundant in the Gulf of Alaska in 2015 (Zador *et al*. 2019), in northern California Current in 2016 (Morgan *et al.* 2019), and off the west coast of Vancouver Island in 2016-2018 (Chandler *et al*. 2017, Boldt *et al*. 2019).

The increase in Northern anchovy was particularly strong in central and southern California, where it serves as high quality prey for many species. Adult anchovy were high in 2018 and the highest ever in 2019 in central California; larval anchovies were also the highest in the CalCOFI time series in 2019. While breeding murres and Brandt's cormorants were apparently unable to take advantage of plentiful anchovy, California sea lions on the Channel Islands did, resulting in very high counts, weights, and growth rates of California sea lion pups in 2018. Humpback whales were also observed congregating near shore along central California in 2013-2019 while feeding on anchovy schools.

One of the more notable increases in abundance has been anadromous American shad (*Alosa sapidissima*), an exotic species that was introduced to the West Coast in the 1800s.

Farther north, the biomass of Pacific herring increased in the Strait of Georgia between 2010 and 2019; during that period, herring were stable off the west coast of Vancouver Island, and decreased in northern British Columbia. Northern anchovy were abundant in the Salish Sea (collectively the Strait of Georgia and Puget Sound) between 2016 and 2019, consistent with increased abundances in years following elevated coastal temperatures (Duguid *et al*. 2019). Juvenile steelhead and salmon of all species, except chum salmon (*O. keta*), were below average off the west coast of Vancouver Island, while chum salmon were abundant. The catch of juvenile salmon in 2017 in two widely-separated surveys targeting juvenile salmon were the lowest in their respective time series. These surveys are used to forecast adult returns and predicted poor returns in future years, some of which have transpired *(e.g.*, the extremely low Columbia River spring-run Chinook salmon (*O. tshawytscha*) return in 2019).

Salmon/Steelhead survival/returns - The abundance of Pacific salmon and steelhead populations from California to Alaska, like other guilds or trophic levels described in this section, have shown dramatic changes in abundance since 2015. While some populations (especially in northern areas) have returned at record high abundances, others have dropped to new lows. For a detailed discussion on the South-Central California Coast Steelhead DPS, *see* Section 2.3 "Updated Information and Current Species' Status."

The recent Pacific salmon and steelhead returns provides context for south-central California steelhead populations. Specifically, it demonstrates that unusually high or low returns are not restricted to any one region, species, or production type (hatchery or wild), but were continent wide. For example, recent low steelhead returns to the Columbia River basin parallel extremely low steelhead returns to the Fraser River basin. In many cases trends of listed species mirror those of hatchery or mixed (hatchery + wild) populations, indicating the critical role that recent unusual environmental conditions have had on Pacific salmon and steelhead.

For further details, see abundances reported from the Pacific States Marine Fisheries Commission (PFMC) 2020 report (psmfc.org), the Pacific Salmon Commission website (PSC.org), Columbia River Direct Access in Real Time (DART) website (cbr.washington.edu), and the Alaska Department of Fish and Game website (www.adfg.alaska.gov).

Concurrent with these changes in the abundance of resident marine fish species was the dramatic northwards change in the spatial distributions of many fishes and some invertebrates in both 2015 and 2019 in response to warmer water. Notable observations included subtropical opah (*Lampris* spp.), billfish (Istiophoriformes), dorado (*Coryphaena hippurus*), dolphin fish (*Coryphaena hippurus*), and yellowtail jack (*Seriola lalandi*) caught off the Oregon and Washington coasts in both years (E. Schindler, personal communication), finescale triggerfish (*Balistes polylepis*) and Louvar fish (*Luvarus imperialis*) off Vancouver Island, and ocean sunfish (*Mola mola*), albacore tuna (*Thunnus alalunga*), Pacific bonito (*Sarda lineolata*), and thresher (*Alopias vulpinus*) and blue sharks (*Prionace glauca*) in Alaska in 2015. There were also tropical sea snakes seen in southern California in 2015, and an invasion of pelagic red crabs (*Pleuroncodes planipes*) that covered the beaches in southern California in 2015 and made it as far north as Newport, Oregon, in 2016.

Seabird productivity – Seabirds consume forage fish that are present at predictable locations and times. Their ability to successfully feed and fledge their chicks (or themselves) is therefore a valuable indicator of the abundance and diversity of forage fish, which support ocean maturing salmon and steelhead. Measures of chick success have varied widely since 2016, and depend on the bird's mode of foraging. Across reported species and locations, in general chick success was low in 2015 and 2016, rebounded in 2017 and 2018 and declined again in 2019.

There have also been several massive seabird die offs in response to the 2014-2016 Northeast Pacific Ocean heat wave (*e.g.,* Cassin's auklet *Ptychoramphus aleuticus,* common murres *Uria aalge*). A rigorous analysis suggests that reduced energy content of zooplankton paired with congregations of birds in a narrow coldwater band along the coast were to blame for the die off (Jones *et al*. 2018). The mortality event affected birds from Alaska to California. Most birds were severely emaciated and, so far, no evidence for anything other than starvation was found to explain this mass mortality (Jones *et al*. 2018, Piatt *et al*. 2020).

Marine mammals – In the California Current, the most obvious impact to marine mammals was the widespread starvation of California sea lion (*Zalophus californianus*) pups in early 2015, resulting in nearly 1,500 malnourished and sick sea lion pups found along California beaches. Strandings in 2015 were the most extreme year in the 2013-2016 period.

Poor feeding conditions in the California Current region in 2015 also led to a dramatic increase in the number of California sea lions farther north that summer, especially in the Columbia River, where they fed on returning adult salmon and steelhead.

The U.S. Global Change Research Program report contains regional-focus chapters for the northwest (Mote *et al.* 2014, Snover *et al.* 2013) and southwest U.S. (Garfin *et al.* 2014). These regional reports synthesize information from an extensive literature review, including a broad array of analyses of regional observations and climate change projections. Updates to this summary can be found in annual literature reviews conducted by NOAA-Fisheries at the following website: http://www.nwfsc.noaa.gov/trt/lcm/freshwater_habitat.cfm.

Historical Climate Trends

Historical records show pronounced warming in both sea-surface and land-based air temperatures. There is moderate certainty that the 30-year average temperature in the Northern Hemisphere is now higher than it has been over the past 1,400 years. In addition, there is high certainty that ocean acidity has increased with a drop in pH of 0.1. In recent decades, the frequency of extreme high temperature or heavy precipitation events has increased in many regions. An anthropogenic influence on this shift in frequency is "very likely" (Intergovernmental Panel on Climate Change 2018, 2021); *see* also, Cook *et al.* (2004).

Regional and local trends include the following observations:

- In both the Northwest and Southwest:
    - air temperatures have increased since the late 1800s
    - springtime snow-water equivalent has decreased (since 1950)
    - snowmelt occurs earlier in the year
- In the Southwest, drought over the past 4 years is unprecedented in the historical record and may be the most severe in over 1,000 years. This drought has been attributed to a

combination of anthropogenic influence on temperature and natural variability in precipitation (Ullrich *et al,* 2018, SWFSC 2022). Trends in precipitation vary spatially up or down, with no statistically significant trends in precipitation averages or extremes in the Northwest.

- In both the Northwest and Southwest, widespread tree mortality has been observed, wildfires have increased in both frequency and area burned, and insect outbreaks have increased (Garfin *et al.* 2014, Mote *et al.* 2014); *see* also, Verkaik *et al.* (2013).
- Historical trends in the California Current are heavily influenced by patterns in wind-driven ocean circulation, which correlates with large-scale climate drivers such as the North Pacific Gyre Oscillation (Peterson *et al.* 2013) and Pacific Decadal Oscillation (Jacox *et al.* 2014). Spatially variable trends in upwelling intensity (Jacox *et al.* 2014) and hypoxia (Peterson *et al.* 2013), and longer trends in atmospheric forcing and sea surface temperature (Johnstone and Mantua 2014) probably reflect natural climate variability to a much greater extent than anthropogenic forcing.
- The pH of the California Current has decreased by about 0.1 and by 0.5 in aragonite saturation state since pre-industrial times (Hauri *et al.* 2009).

Projected Climate Changes

General trends in warming and ocean acidification are highly likely to continue during the next century (National Research Council 2010, Busch *et al*. 2013, Leduc *et al.* 2013, Ou *et al*. 2015, and Bindoff *et al.* 2019).

Among seasons, the greatest temperature shifts are expected in summer. Warmer summer air temperatures will increase both evaporation/evapotranspiration and direct radiative heating. When combined with reduced winter water storage, warmer summer air temperatures will lead to lower minimum flows in many watersheds. Higher summer air temperatures will depress minimum flows and raise maximum stream temperatures even if annual precipitation levels do not change; *see,* for example*,* Sawaske and Freyberg (2014). Summer precipitation also influences summer flows, but projections for precipitation are less certain than for temperature. Coastal weather can differ from region-wide projections due to changes in fog, on-shore winds, or precipitation (Potter 2014, Johnstone and Dawson 2010); *see* also, Lang and Love (2014), NMFS (2021a).

Widespread ecosystem shifts are likely, and may be abrupt due to disturbances from increasing wildfires, insect outbreaks, droughts, and tree diseases (Swanson 1981, Verkaik *et al.* 2013, Garfin *et al.* 2014, Mote *et al.* 2014, Abatzoglou and Williams 2016, Andela *et al*. 2017, Florsheim *et al*. 2017, Cooper *et al*. 2021). Climate projections often favor invasive fish species over native species, with declines exacerbated by the greater vulnerability of native species to existing anthropogenic stressors (Lawrence *et al.* 2012, 2014, Quiñones and Moyle 2014).

In response to projected changes in both climate and land use practices, estuary dynamics and use by salmon and steelhead are expected to change as well, with depth and salinity altered by changing sea level, upwelling regimes, and freshwater input (Yang *et al.* 2015); *see* also, Jacobs's *et al.* (2011), Capelli (2016a), Huber and Carlson (2020). Intense upwelling events can move hypoxic and acidic water into estuaries, especially when freshwater input is reduced (Roegner *et al.* 2011). Sea level projections differ at local vs. global scales due to local wind and temperature trends and land movement. Specifically, the National Research Council (2012) predicted a lower rise in sea level off the coasts of Washington and Oregon (62 cm) than off the coast of California (92 cm) by 2100); *see* also, Sweet *et al*. (2014), Ocean Protection Council (2022).

Higher sea-surface temperatures and increased ocean acidity are predicted for marine environments in general (Bindoff, *et al*. 2019). However, regional marine impacts will vary, especially in relation to productivity. The California Current is strongly influenced by seasonal upwelling of cool, deep, water that is high in nutrients and low in dissolved oxygen and pH.

Ecological effects of climate change in the California Current are very sensitive to impacts on upwelling intensity, timing, and duration. Projections of how climate change will affect upwelling are highly variable across models, with predicted trends ranging from negative to positive (Bakun 1990, Mote and Mantua 2002, Snyder *et al.* 2003, Diffenbaugh *et al.* 2008, Bakun *et al.* 2010, Sydeman *et al*. 2014). An analysis of 21 global climate models found that most predicted a slight decrease in upwelling in the California Current, although there is a latitudinal cline in the strength of this effect, with less impact toward the north (Rykaczewski *et al.* 2015).

Much of the near-shore California Current is expected to be corrosive (*i.e.,* undersaturated in aragonite) in the top 60 m during all summer months within the next 30 years, and year-round within 60 years (Gruber *et al.* 2012). Thermal stratification and hypoxia are expected to increase (Doney *et al.* 2014).

Impacts on Salmon and Steelhead

Studies examining the effects of long-term climate change on salmon and steelhead populations have identified a number of common mechanisms by which climate variation is likely to influence sustainability of Pacific salmon and steelhead populations. These include direct effects of temperature such as mortality from heat stress, changes in growth and development rates, and disease resistance; *see*, for example, Nielsen *et al*. 1994, Nielsen and Ruggerone (2009), Sloat and Osterback (2013), Sloat *et al*.(2014), Sloat and Reeves (2014), Boughton *et al*. (2015). Changes in the flow regime (especially flooding and low flow events) also affect survival and behavior, particularly for rearing juvenile salmon and steelhead. Expected behavioral responses include shifts in seasonal timing of important life-history events, such as adult migration, spawning, fry emergence, and juvenile migration to the ocean. The movement of juvenile steelhead between upstream reaches and the estuary may be disrupted by changes in late spring, summer and early fall base flows (Boughton *et al.* 2009, Hayes, *et al.* 2011, Palmer and Ruhl 2019, Patterson *et al*. 2020).

Indirect effects on salmon and steelhead mortality, growth rates and movement behavior are also expected to follow from changes in the freshwater habitat structure and the invertebrate and vertebrate community, which governs food supply and predation risk (Crozier *et al.* 2008, Independent Scientific Advisory Board 2007, Petersen and Kitchell 2001). Both direct and indirect effects of climate change will vary among West Coast Pacific salmon and steelhead ESUs and DPSs and among populations in the same ESUs and DPSs. Adaptive change in any salmonid population will depend on the local consequences of climate change as well as ESU and DPS-specific characteristics and existing local habitat characteristics.

Because climate has such profound effects on survival and fecundity, salmon and steelhead physiology and behavior are intricately adapted to local environmental conditions. These adaptations vary systematically among populations and are exhibited in traits such as age and timing of juvenile and adult migrations, with potential differences in physiology and migration routes (Quinn 2018). These traits often have a significant plastic (non-genetic) component, which allows them to respond quickly to environmental change. Yet these traits also differ genetically among populations (Carlson and Seamons 2008).

Climate impacts in one life-stage generally affect body size or timing in the next life-stage. For this reason, the cumulative life-cycle effects of climate change must be considered to fully assess the scope of risk to a given population. Even without interactions among life-stages, the sum of impacts in several stages will have cumulative effects on population dynamics. See Figure 23.

In many cases, directional climate change exacerbates existing anthropogenic threats. Examples include streams or rivers where stream temperatures are already elevated due to land-use modifications (Battin *et al.* 2007) or where flow is reduced due to water impoundments, diversions, and groundwater extractions (Walters *et al.* 2013).

Changes in winter precipitation will likely affect incubation and/or rearing stages of most populations. Changes in the intensity of cool-season precipitation could influence migration cues for fall and spring adult migrants, such as coho salmon (*O. kisutc*h) and steelhead. Egg survival rates may suffer from more intense flooding that scours or buries redds (Schuett-Hames *et al.* 1996, May *et al*. 2009, Buxton *et al.* 2015).

Changes in hydrological regime could drive changes in life-history, potentially threatening diversity within a salmon or steelhead ESU/DPS. For example, the juvenile freshwater rearing period is very sensitive to temperature, with the yearling life-history strategy used only by populations in cooler watersheds (Beechie *et al.* 2006, Beighley *et al*. 2008); *see* also, Feng (2019), or watersheds with cooler refugia habitat (Isaak *et al.* 2015, 2016, 2020). Frequency of the yearling life-history type will likely decline as movement downstream into estuaries or near-shore habitat is initiated at younger ages. Implications of this behavioral shift for juvenile survival, ocean migration behavior, and age at maturity are uncertain.

With prolonged exposure to temperatures over 20°C, salmon and steelhead are more likely to succumb to diseases that they might otherwise have survived (Miller *et al.* 2014, Materna 2001); *see* also, McLaughlin *et al.* (2014). Schaaf, *et al*. (2017, 2018). They are also more vulnerable to any sort of stress, such as catch-and-release fisheries (Boyd *et al.* 2010).

Changing hydrology and temperature will also affect the timing of smolt migrations and spawning (Crozier and Hutchings 2014, Hayes and Koick 2014, Otero *et al.* 2014). If smolts migrate at a smaller size because they leave freshwater habitat earlier, they might have lower survival due to size-selective predation (Bond 2006, Bond *et al.* 2008, Hayes *et al.* 2008, Beakes, *et al*. 2010, Thompson and Beauchamp 2014). Marine arrival timing is extremely important for smolt-to-adult survival (Scheuerell *et al.* 2009), and has been historically synchronized with the timing and predictability of favorable ocean conditions (Spence and Hall 2010). Given the uncertain effects of climate change on upwelling timing and intensity, impacts on juvenile survival from shifts in migration timing are also difficult to predict.

In some populations, behavior during the early ocean stage is consistent among years, suggesting a genetic rather than a plastic response to environmental conditions (Hassrick *et al.* 2016, Burke *et al.* 2014). These populations might change their behavior over time if the selective pressures of the landscape changes, but responses will likely be relatively slow and could be dominated by decadal ocean dynamics or productivity outside the California Current (*e.g.,* the Gulf of Alaska for northern migrants).

Other populations show behavior that is more variable after ocean entry (Weitkamp 2010, Fisher *et al.* 2014), and some show heightened sensitivity to interannual climate variation, such as the El Niño/La Niña Southern Oscillation. Such variability might increase West Coast Pacific salmon and steelhead ESU/DPS-level resilience to climate change, assuming some habitats remain highly productive.

Marine migration patterns could also be affected by climate-induced contraction of thermally suitable habitat. Abdul-Aziz *et al.* (2011) modeled changes in summer thermal ranges in the open ocean for West Coast salmon and steelhead under multiple IPCC warming scenarios. For chum salmon, pink salmon (*O. gorbuscha*), coho salmon, sockeye salmon (*O. nerka*) and steelhead, they predicted contractions in suitable marine habitat of 30–50 percent by the 2080s.

Northward range shifts are a climate response expected in many marine species, including salmon and steelhead (Cheung *et al.* 2009, 2015). However, salmon and steelhead populations are strongly differentiated in the northward extent of their ocean migration, and hence will likely respond individually to widespread changes in sea surface temperature.

In most West Coast Pacific salmon and steelhead species, size at maturation has declined over the past several decades. This trend has been attributed in part to rising sea surface temperatures (Bigler *et al*. 1996, Pyper and Peterman 1999, Morita *et al*. 2005). Mechanisms involved in such responses are likely complex, but appear to reflect a combination of density-dependent processes, including increased competition due to higher salmon abundance and temperature (Pyper and Peterman 1999).

Numerous researchers have reported that salmon and steelhead marine survival is highly variable over time and often correlated with large-scale climate patterns (Mueter 2002, 2005, Grimes *et al*. 2007, Litzow *et al*. 2014, Bond *et al.* 2015).

Listing Factor E Other Natural or Man-Made Factors Affecting the Species' Continued Existence: Conclusion

Projected climate change (including droughts and wildfires) and marine warming and acidification is expected to increase the survival risk to the South-Central California Coast Steelhead DPS by deleteriously affecting both freshwater and ocean habitat conditions.

The specific habitat areas of concern for steelhead in the South-Central California Coast Steelhead DPS of Steelhead remain essentially the same, though the COVID-19 pandemic and related economic dislocations have increased impacts to some riparian areas and degraded water quality through increased recreational use of open space areas and increased homeless use of riparian corridors, particularly in areas with developed public access facilities. The threat from "environmental variability" can be expected to increase in the future as a result of projected climate change. Spread of non-native invasive vegetation (which may affect both evapotranspiration rates and invertebrate production important to rearing juvenile *O. mykiss*) is a DPS-wide threat, as is the introduction and spread of non-native aquatic species that prey upon or compete for living space of rearing juvenile *O. mykiss*, as well as serve as vectors for diseases.

Stocking of non-native hatchery reared *O. mykiss* in anadromous waters has ceased, and triploid fish are used in current stocking programs; however, the legacy effects of past stocking of non-native hatchery reared *O. mykiss* persists.

2.4 Synthesis

Under ESA Section 4(c) (2) NMFS must review the listing classification of all listed species at least once every 5 years. 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. While conducting these reviews, NMFS applies the provisions of ESA Section 4(a) (1) and NMFS' implementing regulations at 50 CFR part 424.

NMFS reviews the status of the species and evaluates whether any one of the five listing factors, as identified in ESA Section 4(a)(1) suggests that a reclassification is warranted: (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 a species continued existence. NMFS then makes a determination based solely on the best available scientific and commercial information, taking into account efforts by states and foreign governments to protect the species.

There is little new evidence to indicate that the threatened status of the South-Central California Coast Steelhead DPS has changed appreciably since the last 5-year review (Williams *et al.* 2016, Capelli 2016b). The extended drought (with accompanying wildfires), however, has elevated the threats level to the populations in the South-Central California Coast Steelhead DPS (*i.e*., the Interior Coast Range BPG and Big Sur Coast BPG). The lack of comprehensive monitoring has also limited the ability to fully assess the status of individual populations and the South-Central California Coast Steelhead DPS as a whole; *see* Capelli (2020a), Boughton (2022) in SWFSC (2022).

The systemic anthropogenic threats identified at the time of the initial listing have remained essentially unchanged over the past 5 years, though there has been significant progress in removing small-scale fish passage barriers in a number of the core recovery watersheds. Threats to the South-Central California Coast Steelhead DPS posed by environmental variability resulting from projected climate change are likely to increase, further threatening the threatened South-Central California Coast Steelhead DPS.

2.4.1 DPS Delineation and Hatchery Membership

NMFS' Southwest Fisheries Science Center's review (SWFSC 2022) found that no new information had become available that would justify a change in the delineation of the South-Central California Coast Steelhead DPS.

There is no steelhead hatchery program operating in or serving the South-Central California Coast Steelhead DPS.

2.4.2 DPS Viability and Statutory Listing Factors

NMFS' Southwest Fisheries Science Center's review of updated information (Boughton 2022, in SWFSC 2022) does not indicate a change in the biological risk category, *threatened*, to the South-Central California Coast Steelhead DPS since the time of NMFS' 2016 5-year review (Williams *et al.* 2016).

NMFS' analysis of ESA Section 4(a)(1) factors indicates that the collective risk to the persistence of the South-Central California Coast Steelhead DPS has not changed appreciably since NMFS' 2016 5-year review (Williams *et al.* 2016). While individual populations have been more adversely affected by the extended drought through loss of over-summering juvenile steelhead rearing habitat and the effects of specific wildfires on habitat quality and availability (*e.g.*, Interior Coast Range BPG and Big Sur Coast BPG), the overall level of threat to the South-Central California Coast Steelhead DPS remains the same.

3. Results

3.1 Classification

Listing Status:

Based on the information identified above, we recommend that the South-Central California Coast Steelhead DPS remain classified as a *threatened* species.

DPS Delineation:

The Southwest Fisheries Science Center's review (Boughton 2022 in SWFSC 2022) found that no new information has become available that would justify a change in the delineation of the South-Central California Coast Steelhead DPS.

Hatchery Membership:

There is no steelhead hatchery program operating within or serving the South-Central California Coast Steelhead DPS.

3.2 New Recovery Priority Number

Since NMFS' 2016 5-year review, NMFS revised recovery priority number guidelines and twice evaluated the numbers (NMFS 2019a, NMFS 2022a). Table 4 indicates the number in place for the South-Central California Coast Steelhead DPS at the beginning of the current review (3C). In January 2022, the number remained unchanged.

As part of this 5-year review NMFS re-evaluated 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 this 5-year review NMFS has identified several actions critical to improving the status of the South-Central California Coast Steelhead DPS. NMFS focused on the most important recovery actions to be pursued over the next 5 years, though some of these recovery actions may take longer to fully implement due to technical, funding, or other constraints. The following "Recommendations for Future Actions" highlight those recovery actions having the highest potential to improve the status of the South-Central California Coast Steelhead DPS.

Most fundamentally, improving conditions for South-Central California Coast Steelhead DPS requires continued removal of fish passage impediments; restoration of spawning and rearing habitat, ecologically significant flows, and riparian corridors; removal and control of non-native vegetation and exotic aquatic species; identification and protection of over-summering refugia habitats; and implementation of the updated strategy for steelhead viability monitoring in the South Coast Area.

Fish passage improvements are needed to remedy both partial and complete barriers to migration and reach-scale movement of adults and juveniles within mainstems and tributaries of core recovery population watersheds. Habitat improvements should include attention to instream and estuarine habitat complexity, and the geomorphic and watershed processes that naturally create and maintain habitat functions. Flow protections and improvements are needed to protect all life-history stages and habitats for anadromous and resident *O. mykiss*, by providing flow regimes that mimic unimpaired hydrographs, including the effective management of groundwater resources. Improved population monitoring is needed to better understand the status of individual populations and the South-Central California Coast Steelhead DPS and the larger South-Central California Steelhead Recovery Planning Area.

The following recommendations are intended to focus recovery activities within the South-Central California Coast Steelhead Recovery Planning Area that address the emergent or on-going habitat concerns since the 2016 5-year review—and in a manner that implements the provisions of the South-Central California Coast Steelhead Recovery Plan (NMFS 2013a), which provides more specific guidance for restoration and protection of core recovery populations. The greatest opportunity to advance recovery focuses on five major areas: (1) high priority habitat restoration actions; (2) the prevention of local extirpations of steelhead populations; (3) research, monitoring, and evaluation; (4) key ESA consultations; and (5) improved enforcement of ESA protections.

4.1 High Priority Recovery Actions

Implement the following categories of high priority habitat restoration actions and fish passage projects identified in this 5-year review and NMFS' South-Central Coast California Steelhead Recovery Plan (NMFS 2013a):

- Identify and remove or modify man-made steelhead passage impediments (*e.g*., road crossings, water diversions, flood control structures) in core recovery population watersheds to promote the volitional movement of adult and juvenile *O. mykiss*.
- Complete planning for removal or modification of dams to restore sediment transport and volitional fish passage to and from upper watersheds in the larger interior river systems (*e.g.,* Carmel River, Salinas River, San Antonio River, Nacimiento River, and Arroyo Grande Creek).
- Provide ecologically significant flows below dams and diversions in core recovery population watersheds to support all *O. mykiss* life history stages, including adult migration and spawning, and juvenile incubation, rearing and emigration.

See the discussion of individual passage impediments and stream flow deficiencies in "Listing Factor A: Present or Threatened Destruction, Modification or Curtailment of the Species Habitat or Range" and for individual core recovery population watersheds in each BPG, "Recommended Future Actions over the Next 5 Years toward Achieving Population Viability."

4.2 Preventing Local Extinctions of O. mykiss

The extended drought and drying conditions associated with projected climate change has the potential to cause local extinction of *O. mykiss* populations and thus reduce the genetic diversity of *O. mykiss* within the South-Central California Coast Steelhead Recovery Planning Area. To reduce this risk the following measures should be undertaken:

- Develop and maintain conservation hatchery capability at one or more of the CDFW hatcheries to provide temporary accommodation of fish removed from the wild prevent the extirpation of at-risk populations that contribute significantly to the biodiversity of the South-Central California Coast Steelhead DPS; and
- Explore other means of conserving individual stocks of *O. mykiss* that may face the risk of extirpation *(e.g.,* using other existing facilities at academic institutions or museums, or natural refugia habitats).

See the discussion of extinction threats in "Updated Information and Current Species Status" and "Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes."

4.3 Monitoring and Research

Monitoring

This review of the South-Central California Coast Steelhead DPS confirms the value and need for the California CMP, and the importance of implementing the recently updated California CMP steelhead monitoring strategy for the Southern Coastal Area. Full implementation of the updated strategy for steelhead viability monitoring in the South Coast Area (Boughton *et al.* 2022b) is necessary to more accurately understand the survival risk from various natural and anthropogenic threat sources to the South-Central California Coast Steelhead DPS, and assess the response of the DPS to the various recovery actions that have been undertaken to date, or will be undertaken in the future.

Using the guidance from Boughton *et al*. (2022b) to address these issues, NMFS recommends developing the following, as soon as practicable:

- Estimates of mean 2D density of juvenile steelhead for each BPG;
- Data identifying the location, extent, and persistence of drought refugia in each BPG;
- Estimates of adult steelhead abundance in selected populations, sufficient to evaluate representation and redundancy;
- Estimates of adult rainbow trout abundance, sufficient to evaluate total abundance of adult *O. mykiss* in the region;
- Estimates of smolt production and marine survival in selected populations; and
- Routine genetic monitoring, to track the occurrence and frequency of the Omy5 a haplotype as an indicator of viability.

Additionally, information gathered in accordance with the updated California CMP monitoring strategy for the Southern Coastal Area is designed to refine the population viability criteria through a rigorous statistical analysis of data collected from selected core recovery populations, and includes:

- Selecting and establishing counting stations in core recovery populations as described by Boughton *et al*. (2022b);
- Initiating low-flow Stage 1 surveys in estuaries and sloughs as described by Boughton *et al.* (2022b); this monitoring effort is essential because the lagoon-anadromous form of *O. mykiss* depends on these habitats and is a key component of the life-history diversity whose expression is necessary for the species viability. Estuaries and sloughs should be sampled as a distinct target of estimation for each BPG; and
- Selecting and establishing Life-Cycle Monitoring (LCM) Stations as identified in Boughton *et al.* (2022b). See also Table 14-1, "Potential Locations of South-Central California Steelhead Life-Cycle Monitoring Stations" in NMFS' South-Central California Steelhead Recovery Plan (NMFS 2013a). Note: LCM stations could serve as study sites to address the research topics identified below.

See the discussion of monitoring to determine both the status of individual populations and the South-Central California Coast Steelhead DPS as whole, as well as for revising the individual population viability criteria in "Updated Information and Current Species' Status" and "California Coastal Monitoring Program."

Research

Pursue research into steelhead ecology identified in this 5-year review and in the National Center for Ecological Synthesis and Analysis (NCEAS) Southern steelhead research and monitoring colloquium (Boughton and Capelli 2014). Important research topics include:

Functional Basis for Partial Migration

- Partial migration and life-history crossovers (interactions and interdependency of anadromous and non-anadromous forms of *O. mykiss*)

Habitat Structure and Life-History Strategies

- Ecological factors that promote anadromy
- Reliability of migration corridors
- Role of naturally intermittent river and stream reaches
- Rates of dispersal of fish between non-natal watersheds (meta-population dynamics and interactions/dependence of anadromous and non-anadromous *O. mykiss* populations)
- Develop and refine the use of eDNA in assessing presence/density of *O. mykiss,* metapopulation dynamics, and other potential applications.

Nursery Habitats

- Steelhead-promoting nursery habitats
- Comparative evaluation of seasonal lagoon/estuaries
- Potential nursery role of mainstem habitats;

Interactions with Non-Native Species

- Predation
- Disease

Viability Metrics

- Juvenile and spawner density as an indicator of viability

To support these research efforts and to ensure that the best available science is developed and used to recover the South-Central California Coast Steelhead DPS NMFS should issue Section 10(a)(1)(A) scientific research permits that strategically support the research and monitoring activities outlined above (and discussed in "Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes," "Listing Factor C: Disease and Predation," and "Listing Factor D: Inadequacy of Regulatory Mechanisms"), consistent with the following guidance:

- Prioritize permit applications that address identified research identified by NOAA Fisheries' Southwest Fisheries Science Center – Santa Cruz Laboratory, and monitoring, and/or enhancement activities, including any conservation hatchery operations, in NMFS'

South-Central California Coast Steelhead Recovery Plan (NMFS 2013a: Chpt. 13. South-Central California Coast Steelhead Research, Monitoring, and Adaptive Management; Chpt. 14. Implementation by NMFS);

- Evaluate all proposed research identified by NOAA Fisheries' Southwest Fisheries Science Center – Santa Cruz Laboratory, and/or enhancement activities within the framework of identified threats, recovery strategy, and recovery actions identified in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a: Chpt. 13. South-Central California Coast Steelhead Research, Monitoring, and Adaptive Management; Chpt. 14. Implementation by NMFS);
- Develop a streamlined process for permitting priority research activities to facilitate the implementation of the research program developed by NOAA Fisheries' Southwest Fisheries Science Center – Santa Cruz Laboratory or identified in NMFS' South-Central California Coast Recovery Plan (NMFS 2013a: Chpt. 13. South-Central California Coast Steelhead Research, Monitoring, and Adaptive Management; Chpt. 14. Implementation by NMFS); and
- Support and maintain the national research and enhancement database to track the amount of take authorized under the ESA and the effectiveness of conservation and mitigation measures identified in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a: Chpt. 13. South-Central California Coast Steelhead Research, Monitoring, and Adaptive Management; Chpt. 14. Implementation by NMFS).

See the discussion on research topics in "New Research Relative to the Population-Level Viability Criteria," "Listing Factor B: Overutilization for Commercial, Recreational, Scientific, or Educational Purposes," and "Listing Factor C: Disease and Predation."

4.4 ESA Consultations and Permitting Activities

Initiation, completion, and implementation of requirements (and related studies and performance monitoring) for high priority ESA Section 7 consultations and Section 10 permitting actions for Core 1 recovery populations is essential to remediate the principal threats to the viability of the South-Central California Coast Steelhead DPS and provides one of the most direct means by which NMFS can improve the status of the threatened South-Central California Coast Steelhead DPS. The following consultations and permitting activities address key threats to the South-Central California Coast Steelhead DPS identified in this 5-year review by providing volitional fish-passage and supporting instream flows for Core 1 recovery populations:

- Salinas Valley HCP (Monterey County Water Resources Agency)
- Interlake Tunnel Project, Salinas River (Monterey County Water Resources Agency)
- Upper Llagas Creek Flood Control Project, Pajaro River (U.S. Army Corps of Engineers)
- Lopez Dam Habitat Conservation Plan, Arroyo Grande Creek (County of San Luis Obispo).

See the discussion in "Listing Factor A: Present or Threatened Destruction, Modification or

Curtailment of the Species Habitat or Range", and for a discussion of specific core recovery population watersheds, "Population-Specific Key Emergent or Ongoing Habitat Concerns Since the 2016 5-Year Review" and "Recommendations for Future Actions Over the Next 5 Years Towards Achieving Population Viability."

4.5 Enforcement of ESA Protections

Section 9 of the ESA prohibits any person from harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting a listed species, or attempt to engage in any such conduct. Additionally, activities that include significant habitat modification or degradation that leads to injury or mortality of a listed species by significantly impairing essential behavioral patterns are also prohibited. NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a) identifies core recovery steelhead populations essential for the recovery of the South-Central California Coast Steelhead DPS, and identifies activities that could place steelhead at a high risk of take.

To enhance the effective enforcement of the prohibited take provisions of the ESA, NMFS 's West Coast Region and OLE should increase efforts to implement the enforcement activities previously identified in NMFS' South-Central California Coast Steelhead Recovery Plan (NMFS 2013a, section 14.2.4) and the inadequacies identified in this 5-year review. These include:

- Conduct outreach and provide OLE a summary of the recovery priorities and threats.
- Provide NMFS' OLE a summary of the recovery priorities and major threats to the viability of the South-Central California Coast Steelhead DPS.
- Prioritize those actions and areas deemed the greatest threat or importance for focused efforts to halt prohibited take of listed species.
- Periodically review existing protocols establishing responsibilities and priorities between NMFS and OLE to ensure activities by NMFS staff, when supporting OLE, are focused on the highest threats to core recovery populations.
- Work with OLE on the development of a take statement when a potential take incident is reported and referred to OLE.

See the discussion in "Listing Factor D: Inadequacy of Regulatory Mechanisms" and NMFS (2013a), section 14.2.4. "Implementation by NMFS."

5. References

5.1 Federal Register Notices

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56 FR 58612. 1991. Policy Applying the Definition of Species Under the Endangered Species Act to Pacific Salmon.

61 FR 4722. 1996. Policy Regarding the Recognition of Distinct Vertebrate Population Segments Under the Endangered Species Act.

61 FR 56139. 1997. Proposed Rule: Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead.

62 FR 43937. 1997. Final Rule: Endangered and Threatened Species: Listing of Several Evolutionary Significant Units (ESUs) of West Coast Steelhead.

64 FR 50414. 1999. Final Rule: 4(d) Rule for West Coast Salmon and Steelhead.

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

70 FR 52488. 2005. Final Rule: Endangered and Threatened Species: Designation of Critical Habitat for Seven Evolutionarily Significant Units (ESU) of Pacific Salmon and Steelhead in California.

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84 FR 53117. 2019. Endangered and Threatened Species: Initiation of 5-Year Reviews for 28 Listed Species of West Coast Pacific Salmon and Steelhead.

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86 FR 69372. 2021. Proposed Rule by the U.S. Environmental Protection Agency and the U.S. Army Corps of Engineers. Revised Definition of "Waters of the United States."

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5.3 Personal Communications

D. Baldwin, California Department of Fish and Wildlife, Region 3

D. Boughton, National Marine Fisheries Service, Southwest Fisheries Science Center – Santa Cruz Laboratory

J. Casagrande, National Marine Fisheries Service, West Coast Region, California Coastal Office, Santa Rosa

S. Cooper, University of California, Santa Barbara

H. Garcia, Coastal Habitat Education & Environmental Restoration

M. Hardy, California Conservation Corps, Los Padres Service District

K. Klose, U.S. Forest Service, Los Padres National Forest

B. Le Boeuf, University of California, Santa Cruz

M. Love, University of California, Santa Barbara

M. McGoogan, National Marine Fisheries Service, West Coast Region, California Coastal Office, Long Beach

F. Otte, City of San Luis Obispo

M. Readdie, University of California, Santa Cruz

D. Rundio, National Marine Fisheries Service, Southwest Fisheries Science Center – Santa Cruz Laboratory

W. Stevens, National Marine Fisheries Service, West Coast Region, California Coastal Office, Santa Rosa

T. Williams, National Marine Fisheries Service, Southwest Fisheries Science Center – Santa Cruz Laboratory

NATIONAL MARINE FISHERIES SERVICE
5-YEAR REVIEW

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 South-Central California Coast Steelhead DPS Evaluation Team

REGIONAL OFFICE APPROVAL:

Lead Regional Administrator, NOAA Fisheries

Approve Scott Rumsey — Digitally signed by Scott M. Rumsey Date: 2023.03.13 12:44:41 -07'00' Date: 3/13/13

Cooperating Regional Administrator, NOAA Fisheries

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

Signature________________________ Date: _______

HEADQUARTERS APPROVAL:

Assistant Administrator, NOAA Fisheries

[x] Concur [ ] Do Not Concur

Signature RAUCH.SAMUEL.D.III.1365850948 — Digitally signed by RAUCH.SAMUEL.D.III.1365850948 Date: 2023.04.14 15:13:04 -04'00' Date: _______