UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
777 Sonoma Avenue, Room 325
Santa Rosa, California 95404-4731

May 7, 2021 **Refer to NMFS No:** 151416WCR2019SR00162

Emily Gardner
Deputy General Manager
Salinas Valley Basin Groundwater Sustainability Agency
P.O. Box 1350
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Re: NOAA's National Marine Fisheries Service's Comments on the Upper Valley Subbasin Draft Chapter 8 Rerelease

Dear Ms. Gardner:

NOAA's National Marine Fisheries Service (NMFS) is the federal agency responsible for managing, conserving, and protecting living marine resources in inland, coastal, and offshore waters of the United States. We derive our mandates from numerous statutes, including the Federal Endangered Species Act (ESA). The purpose of the ESA is to conserve threatened and endangered species and their ecosystems.

On April 26, 2021, the Salinas Valley Groundwater Sustainability Agency (SV GSA) rereleased their draft Chapter 8 of the Upper Valley Subbasin Groundwater Sustainability Plan (hereafter referred to as Rereleased Chapter 8). Waterways that overlie portions of the Upper Valley Aquifer Subbasin (e.g., Salinas River) support federally threatened South-Central California Coast (S-CCC) steelhead (*Oncorhynchus mykiss*). A detailed discussion of S-CCC steelhead status and habitat needs, including the importance of the Salinas River to their survival and recovery, is enclosed as Appendix A of this letter.

We conveyed some of the concerns expressed in this letter directly to SV GSA management and their consultant via a video conference call on March 30, 2021. Unfortunately, the Rereleased Chapter 8 does not appear to address many of the concerns previously raised. This letter transmits our comments on the Rereleased Chapter 8.

Comments

Page 8-3, last paragraph: The Rereleased Chapter 8 attempts to characterize and address undesirable results based upon average year conditions "under the reasonably anticipated climatic fluctuations that underpin the future water budget." The Rereleased Chapter 8 also states later in the document (page 8-53) that the undesirable result for streamflow depletion "is established for average year conditions, and as a long-term average over all hydraulic conditions." The focus on "average year conditions" appears to rely on guidance provided in the Department of Water Resources Draft Sustainable Management Criteria Best Management Practices (DWR 2017), which states the following:

> Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.

However, how this statement supports the focus on "average conditions" is unclear, and the SV GSA should clarify the relationship between the two in the final Chapter 8. Furthermore, this guidance was only provided under the "Chronic Lowering of Groundwater Levels" sustainability indicator, and is not included under, and therefore does not pertain to, any other sustainability indicator, including depletions of interconnected surface water. Streamflow depletion impacts that are likely to result in significant effects to S-CCC steelhead and their critical habitat do not occur only during "average year conditions", but are instead most likely to occur during below average and dry water year conditions. Furthermore, central California climate is highly variable, and dry periods have routinely occurred throughout the historical period. In fact, climate change threatens to make those dry periods more frequent and severe. Suggesting dry periods are not a "reasonably anticipated climatic fluctuation" within the Upper Basin subbasin lacks scientific credibility and runs counter to recent research. For example, Diffenbaugh et al. (2015) strongly suggested that global warming is already increasing the probability of conditions that have historically created high-impact drought in California. The surface flow depletion undesirable result should be analyzed and addressed over the entire range of anticipated future climatic conditions, including dry periods.

Page 8-4, last paragraph: The Rereleased Chapter 8 should clarify what is meant by the following statement: "The groundwater elevation (Sustainable Management Criteria; SMC) do (sic) not hinder the interconnected surface water SMC, but also, they do (sic) not prevent unreasonable interconnected surface water depletion by themselves." To achieve sustainable groundwater management, the SV GSA must avoid all undesirable results by 2042, including depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water. If the referenced statement is implying that depletions will be unreasonable, but not significant, and thus are not undesirable results, the Rereleased Chapter 8 should quantify those impacts as they relate to beneficial uses of surface water, and explain why they do not meet the as yet undefined significance threshold. Any such analysis and explanation should address the documented beneficial use of S-CCC steelhead spawning, migration, and cold-water habitat (Central Coast Regional Water Quality Control Board 2017).

Page 8-6: As stated within our previous correspondence on the subject, managing to a level of streamflow depletion consistent with conditions experienced during our recent historic drought (i.e., 2015) is likely to result in adverse impacts to S-CCC steelhead and its critical habitat, and is therefore is an inappropriate minimum threshold, measurable objective, or interim milestone. Furthermore, there is no explanation of how "exceeding the minimum threshold at more than 15 percent of future monitoring wells during average hydrologic conditions" was determined to be an appropriate metric for measuring an undesirable result. The GSP should include an explanation of how this will avoid significant and unreasonable adverse impacts on beneficial uses of the surface water, specifically steelhead spawning, rearing and migration.

Page 8-43: The draft document again alludes to 2015 surface flow depletion rates as being an appropriate definition of an undesirable result because it is "not unreasonable, although it may be significant." The Groundwater Sustainability Plan (GSP) must explain why 2015 groundwater levels will avoid significant and unreasonable adverse impacts on beneficial uses of surface water, including impacts to rearing, migration and cold-water habitat that supports ESA-listed steelhead.

Page 8-43: There are several issues with the second paragraph from the bottom, which reads as follows:

> The minimum threshold for depletion of interconnected surface water is set to the depletion rates observed in 2015, estimated by proxy using shallow groundwater elevations near rivers. These thresholds only apply to river reaches that are hydraulically connected to groundwater when flow in the river is due to either natural runoff, flood releases from a reservoir, or ecological releases from a reservoir. The locations of interconnected surface water should remain the same as 2015 conditions.

To begin with, managing to a streamflow depletion rate consistent with the height of our recent historic drought is inappropriate, and likely to take[1] ESA-listed S-CCC steelhead and its habitat. Second, SGMA regulations require the GSP demonstrate significant correlation between groundwater levels and the other metric (i.e., significant and unreasonable adverse impacts on beneficial uses of the surface water); the Chapter 8 Rerelease, nor any other draft chapter of the developing GSP, has demonstrated the required correlation, nor has a plan been proposed to establish correlation. Finally, locations of interconnected surface water can shift from year to year depending on climatic conditions and groundwater levels. Basing interconnected surface water locations on 2015 observations is inconsistent with hydrologic, geologic, and ecological principles, and would severely underestimate the extent of interconnected surface water during most years.

Page 8-44; Figure 8-5: The figure caption states that interconnected surface water is indicated where that interconnection occurs more than 50 percent of the model period. Per Sustainable Groundwater Management Act (SGMA) regulations, interconnected surface water means surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted. The Chapter 8 Rerelease should explain how the definition presented above is consistent with SGMA regulations.

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[1] Take" is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. "Harm" is further defined by regulation to include significant habitat modification or degradation that actually kills or injures fish or wildlife by significantly impairing essential behavioral patterns, including breeding, spawning, rearing, migrating, feeding, or sheltering (50 CFR 222.102).

Page 8-49: Under "Ecological surface water users", the following statement appears: "Since the reservoir operations consider ecological surface water users and reflect reasonable existing surface water depletion rates, this GSP infers that stream depletion from existing groundwater pumping is not unreasonable." This inference is incorrect. As mentioned in a previous comment letter[2], we withdrew the NMFS's June 21, 2007, biological opinion and associated incidental take statement by letter to the U.S. Army Corp of Engineers and Monterey County Water Resources Agency dated February 20, 2019. Therefore, water releases from Nacimiento Reservoir (and San Antonio Reservoir) have not been analyzed within a valid biological opinion at this time, and assuming that the current flow regime adequately protects beneficial uses of surface water, especially steelhead migration, spawning and rearing, is inappropriate and not supported by any analysis or reasoning.

Page 8-52: Asserting that the proposed minimum thresholds "benefits ecological uses and users by preventing further degradation of ecological impacts from groundwater pumping" is ludicrous. Given that 2015 pumping levels, and the corresponding impact of surface water depletion on beneficial uses, were likely some of the highest on record due to California's historic drought, preventing those impacts from worsening in the future is hardly a "benefit" to ecological users of surface water, and akin to ensuring a dry river channel doesn't get any drier.

We hope these comments effectively clarify and reassert our concerns about potential significant impacts to S-CCC steelhead that are likely to result from the draft Sustainable Management Criteria outlined in the Rereleased Chapter 8 of the Upper Valley GSP. If you have any questions, please do not hesitate to contact William Stevens (707-575-6066, or via email at William.Stevens@noaa.gov) or Rick Rogers (707-578-8552, or Rick.Rogers@noaa.gov) within our Santa Rosa office for further assistance.

Sincerely,

A. Ingham

Amanda Ingham
Central Coast Branch Chief
California Coastal Office

Enclosure

cc: Mark Capelli, NOAA Fisheries Southern California Recovery Coordinator (mark.capelli@noaa.gov)
Annette Tenneboe, CDFW Senior Environmental Scientist Specialist - Central Region (Annette.Tenneboe@wildlife.ca.gov)
Tom Berg, Salinas Valley SGMA Point of Contact South Central Region Office (Thomas.Berg@water.ca.gov)
Natalie Stork, SWRCB Chief -- Groundwater Management Program (Natalie.Stork@waterboards.ca.gov)
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[2] "NOAA's National Marine Fisheries Service's comments on the Final Groundwater Sustainability Plan for the Salinas Valley 180/400-Foot Sub-Basin" (May 8, 2020).

References

Central Coast Regional Water Quality Control Board. 2017. California Central Coast Basin Plan. Copy found at: https://www.waterboards.ca.gov/centralcoast/publications_forms/publications/basin_plan

Diffenbaugh, N.S., D.L. Swain, and D. Touma, D. 2015. Anthropogenic warming has increased drought risk in California. Proceedings of the National Academy of Sciences of the United States of America. 112 (13), 3931–3936.

February 24, 2021

To: William L. Stevens, NMFS West-Coast Region, California Coastal Office, Santa Rosa, CA

From: Mark H. Capelli, NMFS South-Central/Southern California Steelhead Recovery Coordinator, California Coastal Office, Santa Barbara, CA

Re: Role of Salinas River in Meeting NMFS' South-Central California Coast Steelhead Viability/Recovery Criteria.

This is an updated response to the questions regarding the role of the tributaries to the Salinas River in meeting the viability/recovery criteria in the Salinas River watershed, and by extension the viability/recovery South-Central California Coast Steelhead Distinct Population Segment (DPS). The basic analysis conclusion remains the same but is supplemented by recently published research on the ecology and genetics of southern steelhead populations.

In summary, the tributaries to the Salinas River (including the Nacimiento and San Antonio) are essential to meeting the viability/recovery criteria (both the DPS-Wide and Population-Level viability criteria) set forth in NMFS' South Central Southern California Steelhead Recovery Plan (2013). Management of the surface and groundwater resources associated with these tributaries, as well as the mainstem Salinas River is critical to the recovery of this Core 1 population within the Interior Coast Range Biogeographic Population Group (BPG) of the threatened South-Central California Coast Steelhead DPS.

This role of the Salinas River tributaries in the recovery of the steelhead populations of the Salinas River raises a number of related issues and warrants a fuller response, which is provided below.

Introduction

NMFS' Technical Recovery Team (TRT) for the South-Central/Southern California Steelhead Recovery Planning Domain published a series of Technical Memoranda that provides the scientific framework for the recovery of the two listed species in this domain: the threatened South-Central California Coast DPS and the endangered Southern California Steelhead DPS. These Technical Memoranda provide information on:

- the historic distribution of native steelhead and the contraction of the southern range limit;
- a characterization of the ecology of southern steelhead populations;
- an assessment of the intrinsic habitat potential of individual watersheds;

- a suite of viability criteria (for the individual population and the DPS as a whole);

- a general strategy to achieve recovery; and

- a set of research questions to advance understanding of the species and further direct recovery activities.

See Boughton 2010a, 2010b, Boughton *et al*. 2007, 2006a, 2006b, and 2005.

Some of the TRT findings are directly pertinent to your question. These include:

- above artificial barrier *O. mykiss* populations are most closely related to below barrier populations;

- above artificial barrier populations (in a majority of the watersheds) are not descendent from planted hatchery rainbow trout;

- *O. mykiss* populations above artificial barriers have the potential to resume an anadromous life-history; and

- populations of *O. mykiss* above artificial barriers are an integral and important component of the anadromous populations.

See Boughton *et al.* 2006a, Girman and Garza 2006, Garza *et al.* 2004.

These findings have been further substantiated in more recent research: Arostegui *et al*. 2019, Adadia-Cardoza *et al.* 2016, Pearse 2016, Garza *et al.* 2014, Pearse *et al.* 2014, Clemento *et al*. 2009; see also Pearse 2016.

Pearse (2019) and others have further illuminated the genomic mechanisms by which both basic life-history forms of *O. mykiss* (anadromous and non-anadromous) mutually support the persistence of both forms. Pearse *et al.* (2019) and Kelson *et al*. (2019) looked at associations with migration behavior; and Leitwein *et al*. (2017) and Apgar *et al* (2017) examined environmental predictors for a high frequency of the “A” haplotype that is associated with the anadromous form of *O. mykiss*. These recent studies underscore the importance of the non-anadromous form of *O. mykiss* (including those currently land-locked above impassible barriers) and the importance of reestablishing connectivity between the various reaches of the watershed Salinas River watershed (including those reaches above the various dams within the watershed).

Some of their more pertinent findings are summarized below:

- Many of the genes in the inverted section of chromosome 5 of *O. mykiss* (Omy5) are associated with circadian rhythms, sensitivity to photosensory cues, the timing of age at maturity, and other traits associated with life-history variation. Genetic recombination among these different genes of the tightly linked Omy5 segment of the chromosome 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 which prevents cross-over during meiosis. 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* within a watershed (Pearse 2016).

- The two Omy5 haplotypes appear to be associated with different expression of life-history forms (anadromous and resident). Pearse *et al*. (2019) found that in a small steelhead population, juvenile females with the homozygous “AA” and heterozygous “AR” genotypes were much more likely to migrate to the ocean than females with the homozygous “RR” genotype. Juvenile males with the homozygous “AA” and “RR” genotypes were similar to the females, but the male heterozygous “AR” genotype was much less likely to migrate than the female heterozygous “AR” genotype. This 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. 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 heterozygous “AR” females versus “AR” males, but they did find that in general the migration frequency of the “heterozygous AR” genotype was intermediate between the “RR” and “AA” genotypes.

- This intermediate life-history expression of the heterozygous “AR” genotype provides a mechanism by which the steelhead life-history can disappear from an *O. mykiss* population when environmental conditions are adverse but rapidly reappear when conditions favor it. When conditions are adverse, the “A” haplotype may become rare enough that homozygous “AA” individuals are very unlikely and the haplotype is maintained by resident fish carrying the heterozygous “AR” genotype. Notably, 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 heterozygous “AR” smolts that migrate to the ocean. These heterozygous “AR” smolts would likely be lost to mortality when conditions for anadromy are adverse (e.g., presence of anthropogenic barriers to fish passage, prolonged drought, debris flows degrading freshwater habitat, etc.), but could rapidly reconstitute steelhead runs when conditions for anadromy are favorable.

- When favorable conditions persist, adult steelhead would become common enough to start producing “A” individuals, and genetic recombination of the anadromous genome would resume and facilitate continuing adaptive evolution of the anadromous phenotype to changing conditions. A resident-only population may not sustain the A haplotype indefinitely because the “wasted” smolts produced by heterozygous “AR” parents represent a fitness cost, but the loss appears to be a slow process (Apgar *et al*. 2017). Significantly, a similar, reciprocal logic applies to the resident life-history, for example

> providing a mechanism by which heterozygous “AR steelhead could colonize vacant freshwater habitat that eventually transforms to a population of rainbow trout when conditions for anadromy are adverse; hence the emphasis placed on maintaining or restoring volitional access to coastal watersheds. Even when the “A” haplotype is rare in a population, so that homozygous “AA” individuals are unlikely to occur, anadromy is still subject to natural selection due to its partial expression in heterozygous “AR” individuals; and likewise for freshwater-residency and the “R” haplotype.

NMFS South-Central California Coast Steelhead Recovery Plan (2013) recognizes the interdependence of anadromous and non-anadromous life-history forms of native *O. mykiss*. As a result, the Recovery Plan concluded, “Recovery of the threatened SCCCS DPS will require a minimum number of viable populations within each of four Biogeographic Populations Groups (BPGs) within the SCCCS Recovery Planning Area. Recovery of these individual populations is necessary to conserve the natural diversity (genetic, phenotypic, and behavioral) spatial distribution, and abundance of the SCCCS DPS.” (p. xiii) NMFS' Technical Review Team (Boughton *et al.* 2007) also identified “a need to maintain not just the fluvial-anadromous life-history form, but also lagoon-anadromous and freshwater-resident forms in each population” and noted, “Depending on the rate of transition, a group of resident and anadromous fish may function as a single population; two completely distinct populations; or something in between.” (p. 8). Consequently, the resident form of *O. mykiss* is included in the viability criteria developed by the TRT and incorporated into NMFS South-Central California Coast Steelhead Recovery Plan. (p. 6-4).

Because of the close association of the two life-history forms (anadromous and nonanadromous), and the complex of factors controlling the expression of anadromous and resident life-histories, all native *O. mykiss* in anadromous waters (*i.e*., waters within the geographic boundary of the listed DPS and that are accessible to fish migrating from the ocean) are generally considered anadromous and afforded the protections of the ESA.

New research has also documented dispersal of anadromous *O. mykiss* from their natal watershed to non-natal watersheds (Donohoe, *et al*. 2021) which have implications for steelhead recovery and management within the South-Central/Southern California Steelhead Recovery Planning Domain. A study of small coastal stream in the central portion of the SCCCS DPS (Big Creek) revealed that of seven fish opportunistically sampled, all seven had dispersed from their natural 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 nonanadromous 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 did demonstrate that steelhead can disperse considerable distances and nonanadromous females can produce anadromous progeny that can disperse (thus providing genetic connectivity among widely dispersed watersheds). This phenomenon could be an important mechanism for naturally re-colonizing 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*., debris flows, droughts, or catastrophic floods).

NMFS' TRT specifically examined the role of artificial impassible barriers in the extirpation of populations of anadromous *O. mykiss* and the contraction of the southern range limit of the anadromous form. One of the major conclusions of this study was that the majority (68%) of the documented extirpations of the anadromous form of *O. mykiss* were associated with artificial barriers (*e.g.*, dams, culverts, flood-control channels). As a corollary, the probability of occurrence of anadromous *O. mykiss* in a watershed was correlated with the size of the watershed and the amount of accessible spawning and rearing/refugia habitat. Put simply, artificial barriers that affectively impede the migration of anadromous *O. mykiss,* or reduce the amount of spawning and rearing habitat available to the species, increases the likelihood of extirpation of a population. Conversely, restoring access (and therefore the amount of habitat available) increases the viability of the population.

See Boughton *et al.* 2005.

Aside from reducing the amount of spawning and rearing habitat available to steelhead, barriers, such as dams without effective fish passage provisions, have the effect of restricting anadromous *O. mykiss* to below-barrier, lower elevation habitats that are often both hydrologically and thermally less reliable than above-barrier habitats; these adverse conditions are often exacerbated by the artificial flow regimes associated with dams such as San Antonio and Nacimiento dams.

Above-barrier habitats in headwater, tributaries are often spring-fed, which provides suitable year-round rearing habitat (including important refugia habitat during periods of drought).[1] Additionally, above barrier habitats are often characterized boulder pools, with well-developed riparian habitat. These features provides both an important sources of invertebrate food for rearing juvenile *O. mykiss* as well as help to maintain suitable water temperatures, particularly during hot summer months.

Conversely, below-barrier habitats, particularly mainstem habitats are impacted by variety of anthropogenic activities; these include, diversions, floodplain encroachment for agricultural and various urban developments, and related flood control structures and activities that adversely affect the suitability of spawning and rearing habitats. While some studies have shown that below-barrier habitats (including mainstems) can provide high-growth rate opportunities, which lead to larger juvenile size at ocean entry (and thus greater ocean survival), this growth pattern is often associated with the ability of rearing individuals to access the estuary during periods of descending flows. Under unimpaired conditions, many of those juveniles rearing in the mainstem had moved downstream from upstream tributary habitats; but this instream movement is inhibited, or in many completely blocked, as a result of the construction of dams (and diversions) without the inclusion of effective fish passage provisions (including associated flows).

See for example, Quinones, *et al.* 2014, Boughton, *et al.* 2009, Olden and Naiman, 2009, Boughton *et al.* 2007, 2005, Nilsson and Berggren 2000.

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[1] The TRT specifically identified the important role of refugia habitat in headwater tributaries, and recommended that the recovery strategy "identify and maintain sustainable refugia against severe droughts and heat waves". Boughton *et al*. 2007, p. 24.

Given the different advantages of above- and below-barrier habitats, both are necessary to support a viable anadromous population. Where the up and downstream migration of adults and juveniles have been interrupted by impassible barriers, these habitats need to be reconnected. This can be accomplished through either the removal or modification of the barrier, to allow up and downstream migration of both juvenile and adult *O. mykiss*, and the provision of an appropriate flow regime that will promote and facilitate volitional migratory behavior.[2] Where spawning and rearing occurs below the dam (or diversion), a flow release regime must also support these essential fish behaviors.[3]

Consistent with NMFS's TRT recommendations, NMFS' South-Central California Coast Steelhead Recovery Plan identifies recovery actions that address the issue of reconnecting steelhead habitats that have been blocked by fish passage barriers. The DPS-Wide Recovery Actions include the following:

> "Physically modify passage barriers (including dams and diversion facilities identified in Table 7-2 and the BPG [Biogeographic Population Group] recovery action tables) to allow natural rates of migration to upstream spawning and rearing habitats."

See NMFS 2013, p. 8-2, 8.1 "DPS-Wide Recovery Actions".

NMFS' South-Central California Coast Steelhead Recovery Plan also includes watershed-specific recovery actions dealing with barrier removal or modification and related fish passage flows (these are dealt with in more detail in a separate section below on the Salinas River). Additionally, NMFS' Recovery Plan sets forth viability criteria for the DPS, which includes DPS-Wide and Population-Level viability criteria. These criteria describe the characteristics of both the DPS and individual populations that, if met, would indicate that the DPS is viable, and therefore at a low risk of extinction, rendering the DPS eligible for delisting.

The DPS-Wide viability criteria identify a suite of watersheds (steelhead populations) distributed across the landscape in four geographically distinct BPGs, with a minimum number of watersheds[4] in each BPG, and that are intended to address two important elements of the DPS-Wide viability criteria: "Biographic Diversity" and "Life-History Diversity". The Population-Level viability criteria include a number of separate metrics that address various aspects of individual populations ("Mean Annual Run Size", "Ocean Conditions", "Spawner Density", and "Anadromous Faction").

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[2] To address this issue, NMFS' TRT recommended that the recovery strategy secure the extant parts of the inland populations, including the Salinas River in the Interior Coast Range Biogeographic Population Group. The TRT also noted, "The original inland populations were relatively few in number, large in spatial extent, and inhabited challenging environments." Boughton *et al*. 2007, p. 24

[3] The mainstem of the Salinas River is characterized by long alluvial stretches. NMFS' TRT noted that the mainstem of the Salinas River currently does not provide suitable spawning or rearing habitat for steelhead; however, the mainstem prior to Spanish settlement may have been quite different ecologically, and these conditions would have been more conducive to steelhead spawning and rearing. See Boughton, *et al.* 2006, pp. 12, 24, 29, and 98-99.

[4] While the TRT did not have sufficient information to assert that these individual populations were functionally independent (*i.e*., individually viable in an unimpaired stated), it believed that these populations were distinct enough to be considered as separate populations for the purposes of developing the DPS-Wide and Population-Level viability criteria

See NMFS's South-Central California Steelhead Recovery Plan, Chapter 6, Steelhead Recovery Goals, Objectives & Criteria, and Appendix C. Composition of South-Central California Coast Steelhead Recovery Planning Area BPGs.

These are discussed in more detail as they relate to the Salinas River watershed in the separate section below.

Salinas River

The Salinas River is situated within the Interior Coast Range BPG (along with the Pajaro River)[5] and is classified as a Core 1 population within the South-Central California Coast Steelhead Recovery Plan. Core 1 populations are populations identified as having the highest priority for recovery planning based on the following factors:

- intrinsic potential of the population to support a viable population in an unimpaired condition (based on the amount of spawning and rearing habitat);

- the role of the population in meeting the DPS-Wide population viability criteria (minimum number of population per BPG, including spatial distribution, "Biogeographic Diversity", and "Life-History Diversity");

- severity of the threats facing the populations (or current condition of the population;

- potential ecological or genetic diversity of the watershed that contributes to the species overall diversity; and

- capacity of the watershed and population to respond to critical recovery actions needed to address identified threats.

Core 1 populations form the foundation of the recovery implementation strategy and must meet the Population-Level viability criteria identified in NMFS' South-Central California Coast Steelhead Recovery Plan.

See NMFS 2013, Chapter 6, "Steelhead Recovery Goals, Objectives & Criteria" and discussion below for details.

To meet these Population-Level viability criteria NMFS' TRT specifically identified "securing extant inland populations in the Interior Coast Range BPG (Pajaro and Salinas Rivers) and the Carmel Basin BPG (Carmel River)" as a critical component of the recovery strategy for the South-Central California Coast Steelhead DPS.[6] NMFS' TRT further noted, "The populations of the

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[5] See map of Biogeographic Population Groups in the South-Central California Coast Steelhead Recovery Planning Area in NMFS 2013, p. 2-10.

[6] NMF's TRT also recognized the importance of other inland populations within the South-Central/Southern California Steelhead Recovery Planning Domain: "The extant habitat of these populations— especially the anadromous waters of the Pajaro River, Arroyo Seco, the southern Salinas Valley, the Sisquoc River, the Santa Ynez River, the Ventura River and the Santa Clara River—merit high priority for immediate protection and recovery so

Interior Coast Range are particularly important because they appear to have produced the largest run sizes in the SCCCS DPS during years of high rainfall and runoff (Boughton *et al*, 2006, Good *et al*. 2005)."

The Salinas River watershed is unique in several respects that are relevant to the question you have posed.

First, it is the largest watershed within the South-Central California Coast Steelhead Recovery Planning Area (and within the South-Central/Southern California Coast Recovery Planning Domain). Its watershed encompasses approximately 4,391 square miles and extends over almost two degrees of latitude; it is also distinctive in that it runs south to north. The major tributaries of the Salinas (*e.g*., Arroyo Seco, Nacimiento, and San Antonio) are themselves considerably larger than the other individual watersheds within the South-Central California Coast Steelhead Recovery Planning Area.

See Figure 1, map of "Salinas River Major Subbasins".

Second, because of its geographic location and physical features, the Salinas River watershed exhibits the most diverse range of habitat types of all the watersheds within the South-Central/Southern California Coast Recovery Planning Domain: coastal dunes, estuarine marsh, oak woodland, coniferous forest, chaparral, grassland savannah, desert-like scrub, and riparian woodland. This diversity is reflected in the diversity of the native *O. mykiss* populations that occupy and utilize the Salinas River watershed (including anadromous, non-anadromous, and lagoon anadromous forms of *O. mykiss*).

Third, the Salinas River is also unique in that is the only watershed within the South-Central California Coast Steelhead Recovery Planning Area (and within the South-Central/Southern California Steelhead Recovery Planning Domain) for which the TRT has identified multiple populations of anadromous *O. mykiss* in a single watershed.

Multiple Recovery Populations of the Salinas River Watershed

For recovery planning NMFS' TRT for the South-Central/Southern California Coast Steelhead Recovery Planning Domain adopted the one-basin = one population rule. The only exception to this one-watershed/one population rule is the Salinas River watershed[7]. In this watershed, the TRT posited three separate recovery populations. The reason and significance for this characterization of the population structure of the Salinas River is described below.

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that fish passage does not decline further (and should be improved whenever possible, though this is a longer-term effort)." Boughton *et al.* 2007, p. 24.

[7] The TRT identified several other potential situations that could deviate from this rule, but did not have adequate information to propose an alternative population structure: 1) sets of small neighboring basins, such as in Big Sur, the southern Santa Barbara coast, and the Santa Monica Mountains; and 2) neighboring basins with unreliable flow, such as those in the "South of Los Angeles" section of the study area. In these situations, rather than a single watershed supporting multiple discrete populations, individual populations may function as a metapopulations, utilizing multiple watersheds.

As noted, the Salinas River watershed is unusually large, with several significant tributaries (including the Arroyo Seco, Nacimiento, and San Antonio rivers) that join the mainstem of the Salinas River from the west, which are characterized by perennial flow within some reaches, particularly upper reaches and sub-tributaries. These western tributaries are distinctively different from those tributaries that enter the Salinas River from the east (*e.g.*, Estrella River, San Juan Creek) which are more like desert washes. The exception to the eastern tributaries is Gabilan Creek that enters the Salinas System on the extreme northern end of the system. For an overview of the Salinas River watershed See Casagrande, *et al*. 2003; also Hager 2001, Franklin 1999.

Because of the size of the Salinas River watershed, NMFS' TRT examined the possibility that the watershed supported more than one population of anadromous *O. mykiss*. The TRT found that the Salinas River watershed contained five distinct steelhead habitat areas – Gabilan Creek, Arroyo Seco, San Antonio River, Nacimiento River, and the Upper Salinas River system (which includes a number of tributaries, including the Santa Margarita River).

Within these five distinct steelhead habitat areas, the TRT identified three distinguishable populations of anadromous *O. mykiss* within the Salinas River watershed:

1) Gabilan Creek

2) Arroyo Seco

3) Nacimiento River *et al.* (which includes Santa Antonio River and the upper Salinas tributaries)

See Figure 3, map of "Salinas Recovery Populations".

This three-population structure is based on: a) the large size of the Salinas River watershed, b) the distance between the point of entry of anadromous *O. mykiss* into the estuary and the distances between the confluences of the various tributaries with the mainstem of the Salinas River, c) the ephemeral migratory flows within the mainstem, and d) the presumed migratory behavior of the steelhead within the watershed. While the direct evidence from documented fish movement is not sufficient to make a definitive determination regarding total number of distinguishable populations of in the Salinas River watershed, the preponderance of evidence indicates that the Salinas River is capable of supporting at least three discrete populations of anadromous *O. mykiss* within the five distinct steelhead habitat areas.

See Figure 1, map of "Salinas River Major Subbasins" for stream miles and Figure 2, map of "Salinas River Intrinsic Potential Steelhead Spawning and Rearing Habitat" for stream/river miles between confluences.

Gabilan Creek is considered a distinct population because of its unique connection with the ocean via the Temblaldero Slough and the Old Salinas River channel with is connected to the Salinas River Estuary via the Elkhorn Slough. The principal steelhead spawning and rearing habitat is in the upper reaches of Gabilan and has the shortest access route to the Pacific Ocean.

Arroyo Seco is considered a distinct population for several reasons. First, it is separated from the three other upstream steelhead habitat areas by an extended reach of the Salinas River mainstem as a result of naturally ephemeral flow (further exacerbated by dams, diversions, and extensive groundwater pumping). This situation presents significant challenges to juvenile steelhead movement, acting as a mechanism isolating this population from others within the Salinas River watershed. Second, under natural hydrologic conditions *(i.e.*, unimpaired by groundwater extractions, surface water diversions, or dams), there is no evidence that natural low flows would have prevented returning adult steelhead from accessing Arroyo Seco (and thus *forcing* them to spawn in the other steelhead habitat areas of the Salinas River watershed). Third, from a recovery perspective, the adverse consequences of treating Arroyo Seco as indistinct and therefore lumping in it with the other steelhead habitat areas, are greater than splitting or distinguishing it from the other identified populations. (See additional comments below regarding lumping and splitting populations.)

Nacimiento, San Antonio, and Upper Salinas River together comprise a single, distinct population. The combination of the long distance between the point of entry of anadromous *O. mykiss* into the estuary and the confluences of the San Antonio, Nacimiento, and upper Salinas rivers (in conjunction with the ephemeral nature of migration flows, even under unimpaired conditions), frequently prevents adult steelhead from returning to these upper tributaries. As a result, anadromous *O. mykiss* entering the Salinas River are *forced* to spawn in one of the other four steelhead areas supporting the other two distinct recovery populations of the Salinas System (Gabilan Creek or Arroyo Seco), thus segregating the Nacimiento, *et al.* population from the other two recovery populations. Under natural flow conditions, the Nacimiento River exhibits the more reliable migration flows, and so fish natal to the San Antonio River (or Upper Salinas River) that would be forced by low flows in these waters to spawn in the Nacimiento River. NMFS' TRT noted that the Nacimiento and San Antonio rivers both have a high potential as steelhead spawning and rearing habitats, and that these habitats are concentrated in the upper reaches in each watershed above the Nacimiento Dam and San Antonio Dam, respectively.

Contributing to the habitat suitability of the upper reaches of both the Nacimiento and San Antonio rivers is the higher average annual rainfall in these two sub-watersheds. The Salinas River watershed has an overall average annual rainfall of 16.6 inches. By comparison, the Nacimiento River watershed has an average annual rainfall of 26.9 inches, and the San Antonio River watershed an average annual rainfall of 20.2 inches (a 38% and 18% higher average annual rainfall total than the Salinas River watershed, respectively).

See attached Figure 1, map of "Salinas River Major Subbasins" for average annual rainfall totals for the various subbasins of the Salinas River watershed.

In analyzing the population structure of the Salinas River watershed, NMFS' TRT discussed the relative risks, from a recovery perspective, of mistakenly lumping or splitting multiple populations in the Salinas River watershed. The TRT found that the more risky strategy would be to erroneously lump recovery populations. Applying the Population-Level viability criteria to a lumped pair, for example, would not necessarily be sufficient to protect either of the pair (*i.e.*, if neither of the lumped pair of populations met the Population-Viability-Level criteria). Conversely, the opposite strategy - of identifying (splitting) two populations when in reality there is only one functional population - only creates a margin of safety if both populations are recovered to the point that the they individually meet the Population-Level viability criteria. This approach is consistent with the general precautionary principle that the TRT adopted for the two listed species of steelhead at the southernmost end of their range. As the TRT noted, ". . . the bigger risk with respect to recovery appears to be erroneous lumping".

For a detailed analysis of this issue of multiple populations of *O. mykiss* in the Salinas River watershed see, Boughton *et al*. 2005, especially, Section 2.6. "Three Discrete Populations in the Salinas System", Part 4. "Distribution of Steelhead Habitat" and Part 10 Appendices, 10.1. "Evidence for Two or More Populations in the Salinas Basin".

To put this discussion of multiple steelhead populations in the Salinas River watershed in a broader context, it should be recognized that the Salinas River watershed contains approximately two-thirds of the total amount of stream mileage within the South-Central California Coast Steelhead Recovery Planning Area. See NMFS 2013, particularly Tables 9-1, 10-1, 11-1 and 12-1 for comparative stream mileages of the watersheds within the Interior Coast Range BPG and the three other BPGs comprising the South-Central California Coast Steelhead Recovery Planning Area.

Within the Salinas River watershed there are approximately 5,924 stream miles, with the major tributaries historically supporting *O. mykiss* containing 2,081 stream miles, distributed among the tributaries comprising the five steelhead areas, as follows:

Gabilan Creek: 175 miles

Arroyo Seco: 478 miles

San Antonio River: 578 miles

Nacimiento: 527 miles

Santa Margarita Creek: 153 miles

Upper Salinas and tributaries (above Salinas Dam): 170 miles

Of this 2,081 miles, approximately 694 stream miles have been identified has having high intrinsic potential over-summering rearing/refugia habitat (c. 33% of the total stream miles supporting *O. mykiss* within the Salinas River watershed). As noted above, a majority of this over-summering habitat is located in the upper reaches of the tributaries comprising the five steelhead habitat areas within the Salinas River watershed.

Of the three distinguishable recovery populations within the Salinas River, the Nacimiento *et al*. population (which includes the San Antonio River, Nacimiento River, Paso Robles Creek, Santa Margarita River, and Upper Salinas River and tributaries) contains 330 miles of identified high intrinsic potential over-summering rearing/refugia habitat; this represents approximately half (c. 48%) of the total amount of intrinsic potential over-summering habitat associated with the three distinct steelhead populations of the Salinas River watershed. Together, the San Antonio River and Nacimiento River watersheds contain approximately 157 miles of high intrinsic potential over-summering rearing/refugia habitat (74 and 83 miles respectively), and approximately half (c. 48%) of the over-summering habitat within the Nacimiento *et al*. population. Importantly, of the intrinsic potential habitat identified by the TRT in the San Antonio and Nacimiento watersheds, *all* of it is located above the San Antonio and Nacimiento dams.

For stream and intrinsic potential steelhead spawning and rearing habitat mileages, see Figure 1, maps of "Salinas River Major Subbasins", and Figure 2, map of "Salinas River Intrinsic Potential Steelhead Spawning and Rearing Habitat". Also, Boughton, *et al.* 2006 for a detailed discussion of the "envelope method" used to identify intrinsic potential steelhead over-summering habitat, and the associated intrinsic potential maps.

NMFS' TRT Viability Criteria

The DPS-Wide viability criteria for South-Central/Southern California Coast Steelhead Recovery Planning Domain provides that each BPG be comprised of a suite of restored core watersheds, each of which must meet the Population-Level viability criteria. As noted above, individual watersheds were generally presumed to support a single population that would meet the Population-Level viability criteria. However, in the case of the Salinas River, NMFS' TRT recognized multiple populations, each of which must meet the Population-Level viability criteria to address the "Geographic Diversity and "Biological Diversity" elements of the viability criteria. Failure to reconnect the upper and lower watersheds of the San Antonio River and Nacimiento River by providing fish passage around the San Antonio and Nacimiento dams for both juvenile and adult *O. mykiss* would effectively preclude meeting the Population-Level viability criteria for the Nacimiento *et al*. population of the Salinas Watershed, where all of the high intrinsic potential over-summering rearing/refugia habitats exists in the headwater tributaries above the two dams.

Thus, not providing effective fish passage over the Nacimiento and San Antonio dams effectively precludes the recovery of the South-Central California Coast Steelhead DPS because it would prelude meeting the DPS-Wide viability criteria that requires a suite of restored core watersheds. NMFS' South-Central California Coast Steelhead Recovery Plan, specifically requires recovery of the Pajaro River, Gabilan Creek, Arroyo Seco, and Upper Salinas Basin in the Interior Coast Range BPG.

See NMFS 2013, Appendix C. "Composition of South-Central California Coast Steelhead Recovery Planning Area BPGs".

Salinas River Recovery Actions

To meet both the DPS-Wide and Population-Level viability criteria identified by NMFS' TRT for the South-Central California Coast Steelhead Recovery Planning Area, NMFS' South-Central California Coast Steelhead Recovery Plan identified a suite of recovery actions, including those dealing with flows and fish passage at impassible barriers on the suite of Core 1 populations identified in the Recovery Plan.

The DPS-Wide Recovery Actions include a general recovery action involving the physical modification of fish passage barriers identified in Table 7-2 and the BPG recovery action tables. Table 7-1 identifies the Core 1, 2 and 3 *O. mykiss* populations within the South-Central California

Coast Steelhead Recovery Planning Area. Core 1 populations are highlighted in bold face, and include the "Salinas River Watershed (all populations)". See NMFS 2013, p. 7-7.

NMFS' South-Central California Coast Steelhead Recovery Plan also identifies critical recovery actions for each Core 1 population for each BPG. Table 9-3, "Critical recovery actions for Core 1 populations within the Interior Coast Range BPG" identified critical recovery actions for the Salinas River, including the Arroyo Seco, San Antonio, and Nacimiento rivers. These critical recovery actions include physically modifying the dams "to allow steelhead natural rates of migration to upstream spawning and rearing habitats, and passage of smolts, kelts downstream to the estuary and the ocean" for the San Antonio Dam, Nacimiento Dam, and Salinas Dam, on the San Antonio, and Nacimiento, and Salinas rivers, respectively. See NMFS 2013 p. 9-18.

In addition, NMFS' South-Central California Coast Steelhead Recovery Plan identifies watershed-specific recovery actions dealing with the provision of flows and fish passage at the San Antonio Dam, Nacimiento Dam, and Salinas Dam, as well as other fish passage barriers or impediments within the Salinas River watershed.

The most pertinent to the question of providing fish passage and related flows at the San Antonio and Nacimiento dams are:

- Recovery Actions: SAnt-SCCCS-4.1, SAnt-SCCCS-4.2, and SAnt-SCCCS-4.3 (San Antonio River Dams and Surface Water Diversions);

- Recovery Actions: Nac-SCCCS-4.1, Nac-SCCCS-4.2, and Nac-SCCCS-4.2 (Nacimiento Dams and Water Diversions).

There is also a comparable recovery action for the Salinas Dam.

- Recovery Actions: Sal-SCCCS-4.1, Sal-SCCCS-4.2, and Sal-SCCCS-3.3 (Salinas River Dams and Surface Water Diversions)

In addition, there are specific recovery actions dealing with other types of fish passage impediments within the Salinas River watershed; these include:

- Recovery Actions: Sal-SCCCS-3.1 and Sal-SCCCS-3.2 (Salinas River Culverts and Road Crossings);

- Recovery Actions: SAnt-SCCCS-3.1 and SAnt-SCCCS-3.2 (San Antonio River Culverts and Road Crossings);

- Recovery Actions: Nac-SCCCS-3.1 and Nac-SCCCs-3.2 (Nacimiento Culverts and Road Crossings).

See NMFS 2013, pp. 9-31 – 9-32; 9-45 – 9-46; and 9-50; also, NMFS 2016a.

These recovery actions are intended to provide appropriate flows below dams and diversions and related fish passage (for both adult and juvenile *O. mykiss*) around the and San Antonio, Nacimiento, and Salinas dams. The basic goal of these recovery actions is to reconnect up and downstream migratory, spawning and rearing habitats to accommodate the various life-history forms and migratory patterns of native *O. mykiss* within the Salinas River watershed. They are also intended to enable the Salinas River to meet the Population-Level viability criteria identified by NMFS' TRT, and incorporated into NMFS' South-Central California Coast Steelhead Recovery Plan (including the "Biogeographic Diversity" and "Life-History Diversity" elements of the viability criteria).

There are also other recovery actions that are pertinent to the management of San Antonio, Nacimiento, and Salinas dams and the steelhead populations within the Salinas River watershed; these include recovery actions dealing with flood control, non-native species, recreational facilities, and variety of up-slope activities. See NMFS 2013, particularly Table 9-5. "South-Central California Coast Steelhead DPS Recovery Action Table for Lower Salinas River and Sub-Watersheds (Interior Coast Range BPG)", pp. 9-31 – 9-53.

Summary and Conclusion

Failure to provide passage at the San Antonio and Nacimiento dams would result is separating 157 miles of high intrinsic potential over-summering rearing/refugia habitat from the anadromous waters of the Salinas River watershed. This represents c. 48%. of the total amount of high intrinsic potential over-summering spawning/refugia habitat within the Nacimiento *et al.* recovery population, and c. 23% of the total amount of high intrinsic potential over-summering rearing/refugia habitat within the Salinas River watershed. Importantly 100% of the total amount of high intrinsic potential over-summering rearing/refugia habitat (sustained by higher annual average rainfall) within the San Antonio River/Nacimiento River portion of the Nacimiento *et al.* recovery population is located above the San Antonio and Nacimiento dams.

In addition, failure to rectify the fish passage impediments (and related flows) at the San Antonio and Nacimiento dams would preclude meeting the "Geographic Diversity" and "Biological Diversity" elements of the Population-Level viability criteria within the Salinas River watershed, and within the South-Central California Coast Steelhead DPS as a whole.

As NMFS' South-Central California Coast Steelhead Recovery Plan noted:

> "Regarding the impacts of impassable anthropogenic barriers on threatened steelhead, the recovery objectives include restoring steelhead distribution to previously occupied areas and restoring genetic diversity and natural interchange within populations and metapopulations. One of the threats abatement criteria identified to meet these objectives is allowing sustainable effective access to historical spawning and rearing habitats."

NMFS South-Central California Coast Steelhead Recovery Plan includes the following critical recovery actions for the Salinas River:

> "Develop and implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases from Salinas Dam[s] to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify all fish passage impediments, including the Salinas Dam[s],

> to allow steelhead natural rates of migration to upstream spawning and rearing habitats, and passage of smolts and kelts downstream to the estuary and ocean. Management of instream mining to minimize impacts to migration, spawning, and rearing habitat, and protect spawning and rearing habitat in major tributaries, including the Arroyo Seco. Identify, protect, and where necessary restore estuarine rearing habitats, including management of artificial breaching of the sandbar at the river's mouth."

Table 9-3. "Critical recovery actions for Core 1 populations within the Interior Coast Range BPG", p. 9-18.

The San Antonio and Nacimiento dams were specifically identified in NMFS' South-Central California Coast Steelhead Recovery Plan "Critical Recovery Actions":

> "Physically modify San Antonio Dam to allow steelhead natural rates of migration to upstream spawning and rearing habitats, and passage of smolts and kelts downstream to the estuary and the ocean."
>
> "Physically modify Nacimiento Dam to allow steelhead natural rates of migration to upstream spawning and rearing habitats, and passage of smolts and kelts downstream to the estuary and the ocean."

NMFS' 2013, Recovery Actions SAnt-SCCCS-4.1, SAnt-SCCCS-4.2, Sant-SCCCS-4.3 and Nac-SCCCS-4.1, Nac-SCCCS-4.2, Nac-SCCCS-4.3, pp 9-45 through 9-46, 9-50.

I hope that this analysis will provide a useful framework in which to consider NMFS' recovery actions for the Salinas River watershed identified in NMFS' South-Central California Coast Steelhead Recovery Plan.[8]

[8] For examples of the analyses of impacts and approaches to providing effective fish passage at other major dams within the South-Central/Southern California Steelhead Recovery Planning Domain, see, California State Water Resoruces Control Board 2019, and NMFS 2016b, 2008.

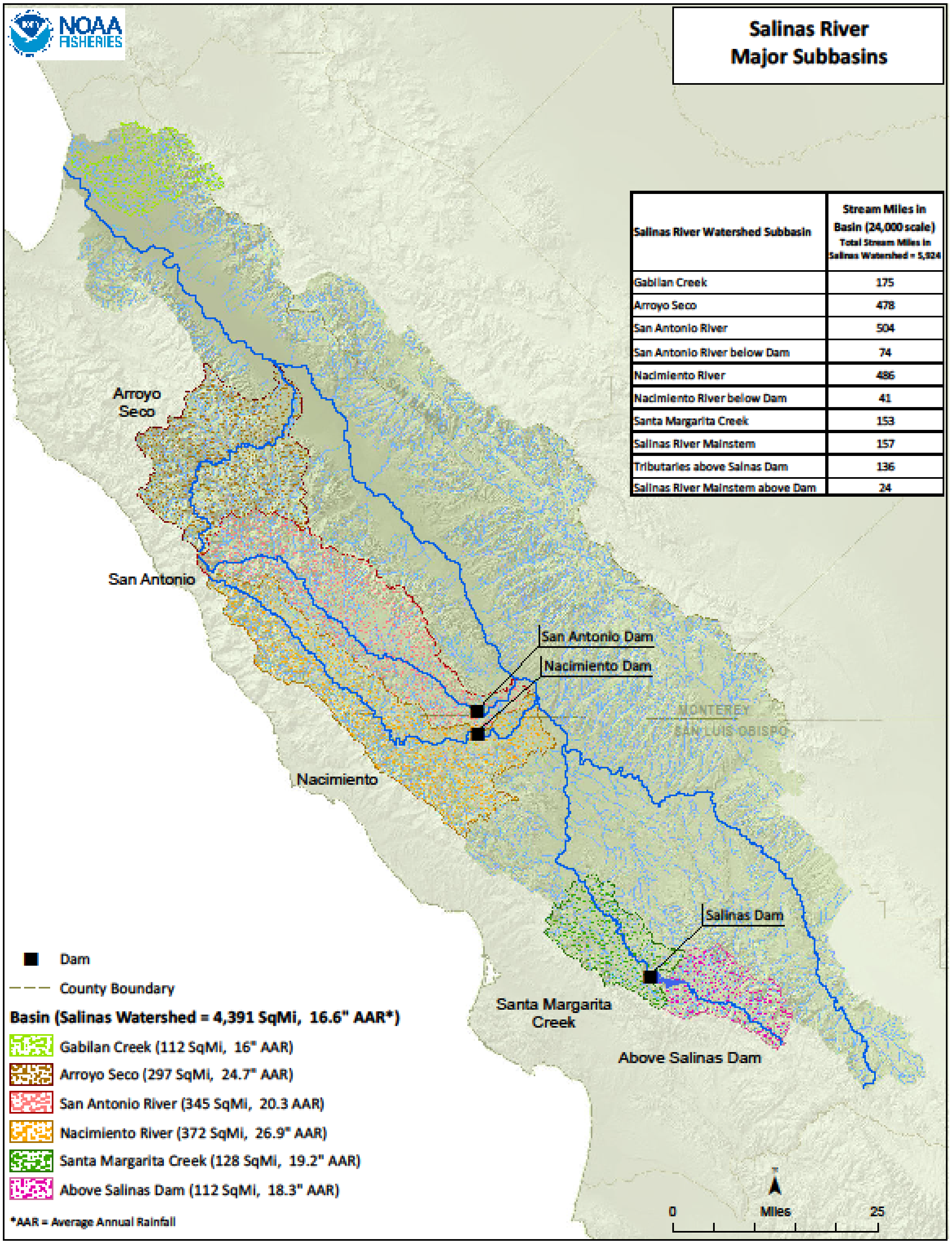

Figure 1. Salinas River Major Subbasins.

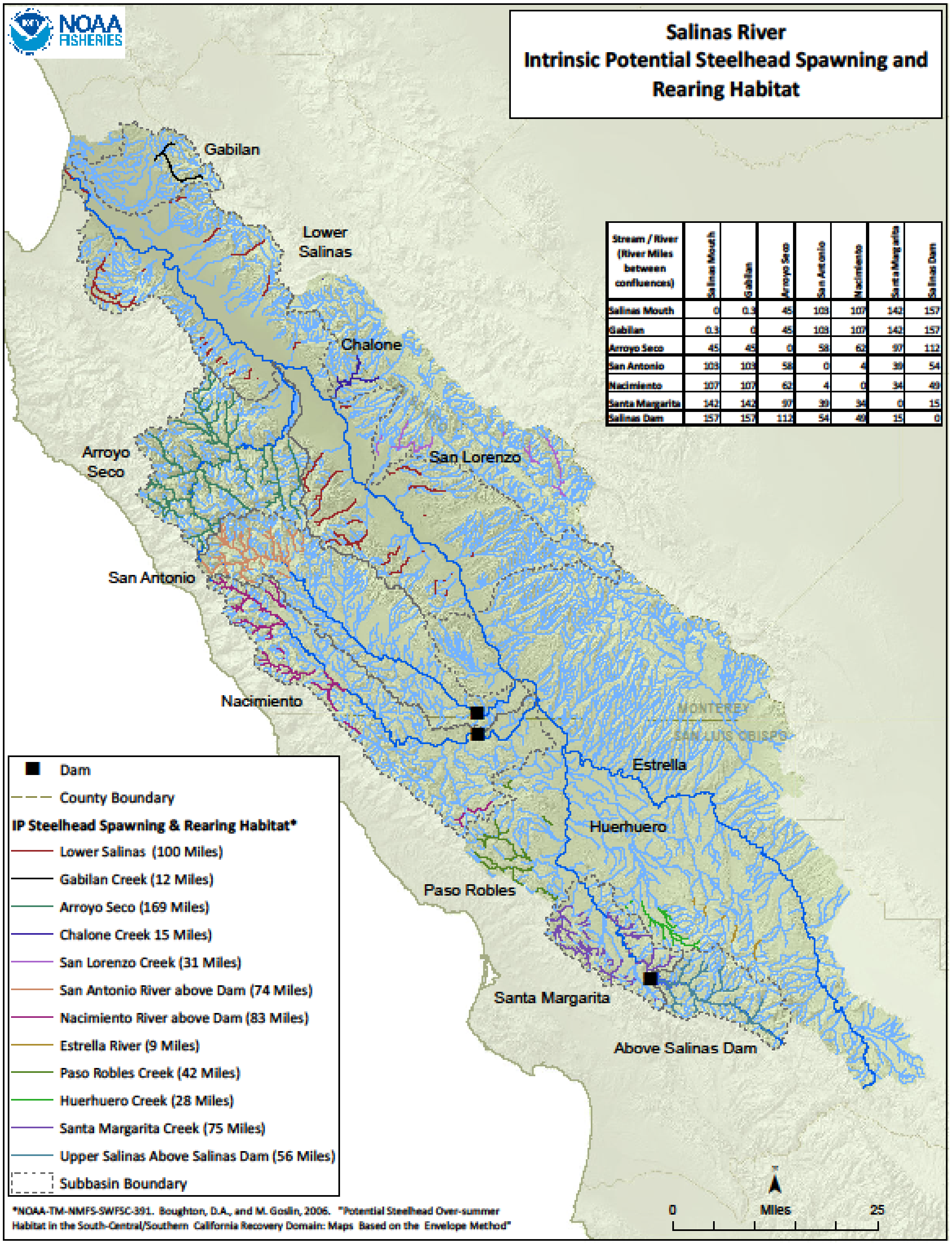

Figure 2. Salinas River Intrinsic Potential Steelhead Spawning and Rearing Habitat.

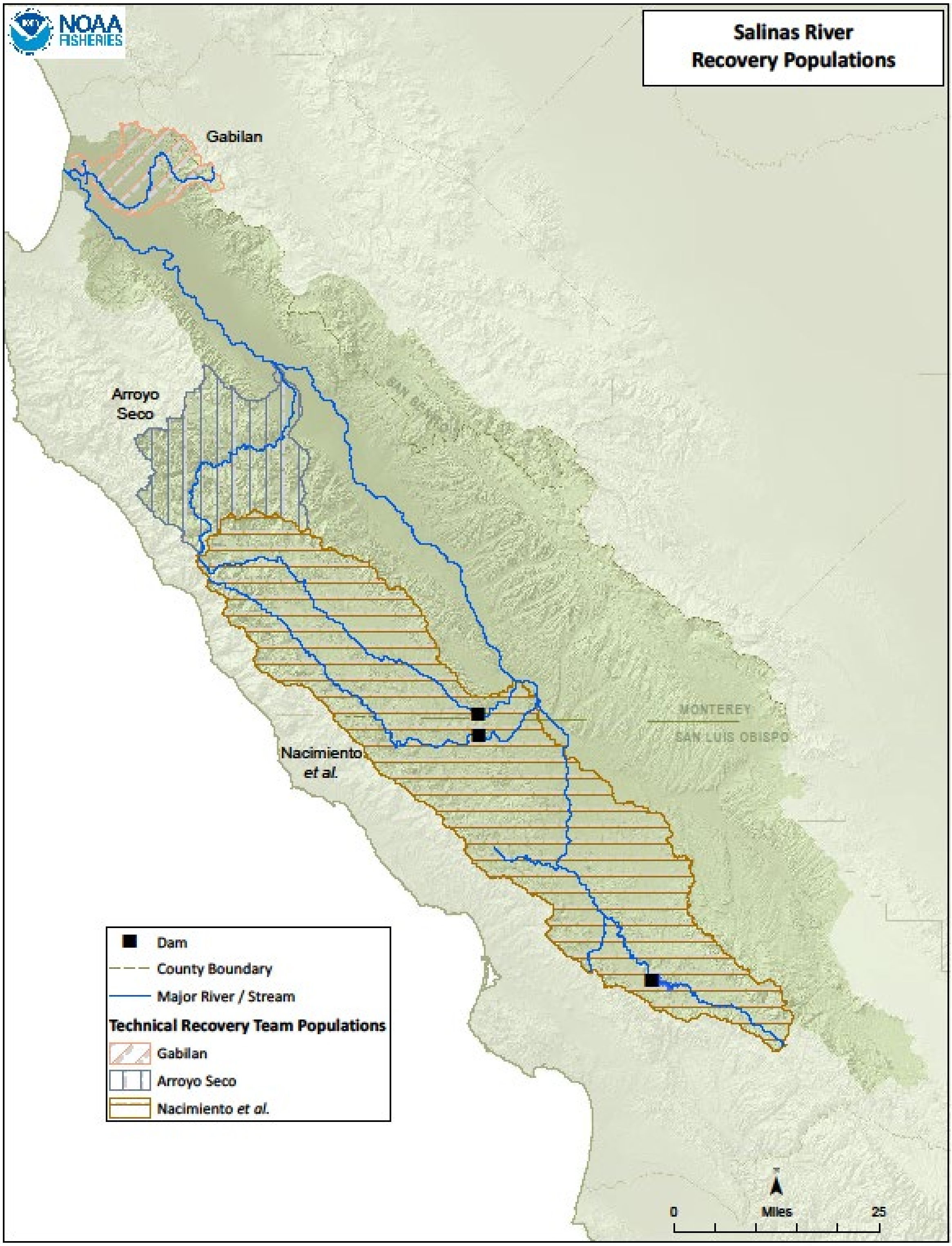

Figure 3. Salinas River Recovery Populations.

References

Adadia-Cardoso, A., D. E. Pearse, S. Jacobson, J. Marshall, D. Dalrymple, F. Kawasaki, G. Ruiz-Campos and J. C. Garza. 2016. Population genetic structure and ancestry of steelhead/rainbow trout (*Oncorhynchus mykiss*) at the extreme southern edge of their range in North America. *Conservation Genetics* DOI 10.1007/s10592-016-0814-9.

Apgar, T. M., D. E. Pearse, and E. P. Palkovacs. 2017. Evolutionary restoration potential evaluated through the use of train-linked genetic marker. *Evolutionary Applications* 10(5): 485-497.

Arostegui, M. C., T. P. Quinn, L. W. Seeb, and G. J. McKinney. 2019. Retention of a chromosomal inversion from an anadromous ancestor provides the genetic basis for alternative freshwater ecotypes in rainbow trout. *Molecular Ecology. Special Issue. The Role of Structural Variants in Adaptation and Diversification* 28(6): 1112-1247.

Boughton, D. H. 2010a. A Forward-Looking Scientific Frame of Reference for Steelhead Recovery on the South-Central and Southern California Coast. NOAA Technical Memorandum NMFS-SWFSC-466.

Boughton, D. H. 2010b. Some Research Questions on Recovery of Steelhead on the South-Central California Coast. NOAA Technical Memorandum NMFS-SWFSC-467.

Boughton, D., H. Fish, J. Pope and G. Holt. 2009. Spatial patterning of habitat for *Oncorhynchus mykiss* in a system of intermittent and perennial stream. *Ecology of Freshwater Fish* 18:92-105.

Boughton, P. Adams, E. Anderson, C. Fusaro, E. Keller, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. Regan, J. Smith, C. Swift, L. Thompson, F. Watson. 2007. Viability Criteria for Steelhead of the South-Central and Southern California Coast. NOAA-Technical Memorandum NMFS-SWFSC-407.

Boughton, D. A., P. Adams, E. Anderson, C. Fusaro, E. A. Keller, E. Kelley, L. Lentsch, J. Nielsen, K. Perry, H. M. Regan, J. J. Smith, C. Swift, L. Thompson, and F. Watson. 2006a. Steelhead of the South-Central/Southern California Coast: Population Characterization for Recovery Planning. NOAA Technical Memorandum NMFS-SWFSC-394.

Boughton, D. A. and Goslin, M. 2006b. Potential steelhead over-summering habitat in the South-Central/Southern California coast recovery domain: Maps based on the envelope method. *NOAA Technical Memorandum NMFS-SWFSC* 391.

Boughton, D.A., H. Fish, K. Pipal, J. Goin, F. Watson, J. Hager, J. Casagrande, and M. Stoecker. 2005. Contraction of the southern range limit for anadromous *Oncorhynchus mykiss*. *NOAA Fisheries Technical Memorandum SWFSC* 380.

California State Water Resources Control Board. 2019. State of California State Water Resources Control Board Order WR 2019-0148 In the Matter of Permits 11308 and 11310 (Applications

11331 and 11332) held by the United States Bureau of Reclamation for the Cachuma Project on the Santa Ynez River. Order Amending Permits 11308 and 11310.

Casagrande, J., J. Hager, and F. Watson. 2003. Fish species distribution and habitat quality for selected streams of the Salinas watershed. The Watershed Institute, California State University Monterey Bay.

Clemento, A. J., Anderson, E. C., Boughton, D., Girman, D., and Garza, J. C. 2009. Population genetic structure and ancestry of *Oncorhynchus mykiss* populations above and below dams in south-central California. *Conservation Genetics* 10:1321–1336.

Donohoe, C. J., D. E. Rundio, D. E. Pearse, T. H. Williams. 2021. Straying and life history of adult steelhead in a small California coastal stream revealed by otolith natural tags and genetic stock identification. *North American Journal of Fisheries Management* doi.1002/NAAFM.10577.

Franklin, H. A. 1999. Steelhead and salmon migration in the Salinas River. Unpublished report, H. Franklin, 1040 South River Road, Paso Robles, CA 93446.

Garza, J. C., L. Gilbert-Horvath, B. Spence, T. H. Williams, J. Anderson, and H. Fish. 2014. Population structure of steelhead in coastal California. *Transactions of the American Fisheries Society* 143:134-152.

Garza, J.C., L. Gilbert-Horvath, J. Anderson, T. Williams, B. Spence and H. Fish. 2004. Population structure and history of steelhead trout in California. *NPAFC Technical Report* No. 5.

Girman, D. and J.C. Garza. 2006. Population structure and ancestry of *O. mykiss* populations in South-Central California based on genetic analysis of microsatellite data. Final Report for California Department of Fish and Game Project No. P0350021 and Pacific States Marine Fisheries Contract No. AWIP-S-1, September 2006.

Good, T. P., R. S. Waples, and P. Adams (eds.) 2005. Updated Status of Federally Listed ESUs of West Coast Salmon and Steelhead. National Marine Fisheries Service. Northwest and Southwest Fisheries Science Centers. NOAA Technical Memorandum NMFS-NWFSC TM-66.

Hager, J. 2001. An Evaluation of Steelhead Habitat and Population in the Gabilan Creek Watershed. Capstone Project, Earth Systems and Policy, Center for Science, Technology, and Information Resources. California State University, Monterey Bay.

Kelson, S. J., M. R. Miller, T. Q. Thompson, S. M. O'Rourke, and S. M. Carlson. 2019. Do genomics and sex predict migration in a partially migratory salmonid fish, *Oncorhynchus mykiss*? *Canadian Journal of Fisheries and Aquatic Sciences* 76:2080-2088.

Leitwein, M., J. C. Garza, and D. E. Pearse. 2017. Ancestory and adaptive evolution of anadromous, resident, and adfluvial rainbow trout (*Oncorhynchus mykiss*) in the San Francisco bat area: application of adaptive genomic variation to conservation in highly impacted landscape. *Evolutionary Applications* 10(1):56-67.

National Marine Fisheries Service. 2016a. South-Central/Southern California Coast Steelhead Recovery Planning Domain. 5-Year Review: Summary and Evaluation. South-Central California Coast Steelhead Distinct Population Segment. National Marine Fisheries Service. West Coast Region. California Coastal Office, Santa Rosa, California.

National Marine Fisheries Service. 2016b. Endangered Species Act (ESA) Section 7(a)(2) Draft Biological Opinion. Operation and Maintenance of the Cachuma Project [Santa Ynez River]. NMFS Consultation Number: 2014-1014, Action Agency: U.S. Bureau of Reclamation.

National Marine Fisheries Service. 2013. South-Central California Coast Steelhead Recovery Plan. NOAA Fisheries. West Coast Region, California Coastal Office, Long Beach, California.

National Marine Fisheries Service. 2008. Final Biological Opinion. Operation of the Santa Felicia Hydroelectric Project (P-2153)-012). Action Agency: U. S. Federal Energy Regulatory Commission, Washington, D. C., license issued to United Water Conservation District. May 5, 2008. Tracking **#:** SWR/2002/02704.

Nilsson, C. and K. Berggren. 2000. Alteration of riparian ecosystem caused by river regulation. *BioScience* 50(9):783-792.

Olden, J.D. and R. J. Naiman. 2009. Incorporating thermal regimes into environmental flow assessments: modifying dam operations to restore freshwater ecosystem integrity. *Freshwater Biology* 85(1).

Pearse, D. E., N. J. Barson. T. Nome, G. T. Gao, M. A. Campbell, A. Abadia-Cardoso, E. C. Anderson, *et al.* 2019. Sex-dependent dominance maintains migration supergene in rainbow trout. *Nature Ecology & Evolution* 3(12):173-1742.

Pearse, D. E. 2016. Saving the Spandrels? Adaptive genomic variation in conservation and fisheries management. *Journal of Fish Biology*, doi: 10.1111/jfb.13168

Pearse, D. E., M. R. Miller, A. Abadia-Cardoso, and J. C. Garza. 2014. Rapid parallel evolution of standing variation in a single, complex, genomic region is associated with life-history in steelhead/rainbow trout. *Proceedings of the Royal Society* B-Biological Sciences [online serial] 281: article 2014.0012.

Pearse, D. and J. C. Garza. 2008. Historical Baseline for Genetic Monitoring of Coastal California Steelhead, *Oncorhynchus mykiss.* Final Report for California Department of Fish and Wildlife Fisheries Restoration Grant Program P0510530.

Quinones, R. M., T. E. Grantham, B. N. Harvey, J. D. Kiernan, M. Klasson, A. P. Wintzer, P. B. Moyle. 2014. Dam removal and anadromous salmonids (*Oncorhynchus* spp.) Conservation in California. *Review Fish Biology Fisheries*. DOI 10.1007/s1160-014-9359-5.