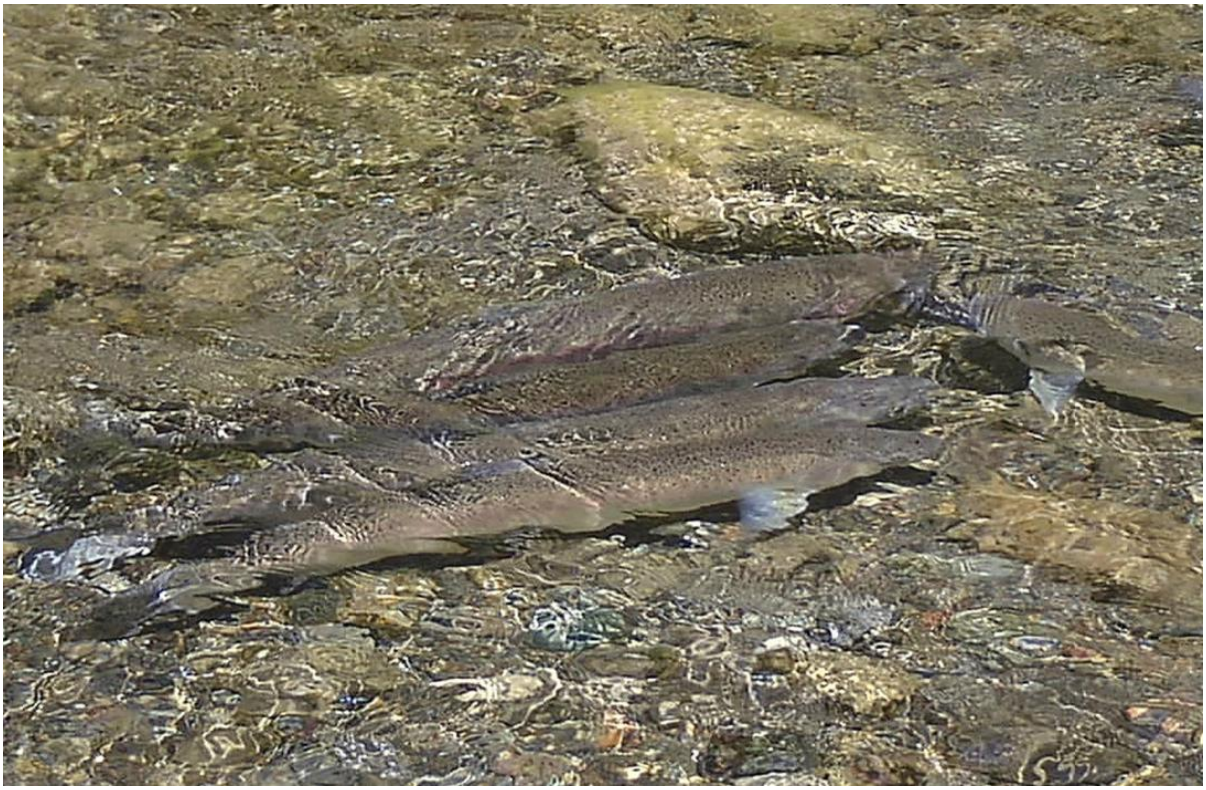
SOUTH-CENTRAL CALIFORNIA STEELHEAD RECOVERY PLAN

Public Review Draft



Southwest Regional Office
National Marine Fisheries Service
Long Beach, CA

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EXECUTIVE SUMMARY

The goal of this Recovery Plan is *to prevent the extinction of South-Central California Coast steelhead (Oncorhynchus mykiss) in the wild and to ensure the long-term persistence of viable, self-sustaining, populations of steelhead distributed across the South-Central California Coast Steelhead (SCCCS) Distinct Population Segment (DPS). It is also the goal of this Recovery Plan to establish a sustainable South-Central California steelhead sport fishery.*

Recovery of the SCCCS DPS will require the protection, restoration, and maintenance of a range of habitats throughout the DPS in order to allow the natural diversity of *O. mykiss* to be fully expressed (*e.g.*, anadromous and resident forms, timing and frequency of runs, and dispersal between watersheds).

Status of South-Central California Coast Steelhead

Steelhead are the anadromous, or ocean going form of the species *Oncorhynchus mykiss*, with adults spawning in freshwater, and juveniles rearing in freshwater before migrating to the ocean to grow and sexually mature before returning as adults to reproduce in freshwater. Steelhead populations along the West Coast of North America have experienced substantial declines as a result of human activities such as water development, flood control programs, forestry practices, agricultural activities, mining, and urbanization that have degraded, simplified, and fragmented aquatic habitats. In South-Central California, near the southern limit of the range for anadromous *O. mykiss* in North America, it is estimated that annual runs have declined dramatically from an estimated 25,000 returning adults historically, to currently less than 500 returning adults (Williams *et al.* 2011, Good *et al.* 2005, Helmbrecht and Boughton 2005, Boughton and Fish 2003).

Steelhead along South-Central California Coast comprise a "distinct population segment" of the species *O. mykiss* that is ecologically discrete from the other populations of *O. mykiss* along the West Coast of North America. Under the U.S. Endangered Species Act of 1973 (ESA), this DPS qualifies for protection as a separate species. In 1997, the SCCCS DPS - originally referred to as an Evolutionarily Significant Unit (ESU) - was listed as a "threatened" species - a species that is likely to become in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

South-Central California Steelhead Angling Heritage – Salinas River c. 1940s.

Recovery Planning

The ESA mandates that the National Marine Fisheries Service (NMFS) develop and implement Recovery Plans for the conservation (recovery) of listed species. The development and implementation of a Recovery Plan for the SCCCS DPS is considered vital to the continued persistence and recovery of anadromous *O. mykiss* in South-Central California.

The SCCCS DPS encompasses *O. mykiss* populations in watersheds from the Pajaro River (Monterey County) south to Arroyo Grande

Creek (San Luis Obispo County). For recovery planning purposes, the South-Central California Coast Steelhead (SCCCS) Recovery Planning Area includes those portions of coastal watersheds that are seasonally accessible to anadromous *O. mykiss* entering from the ocean, including the upper portions of watersheds above anthropogenic fish passage barriers that historically contributed to the maintenance of anadromous populations.

Recovery plans developed under the ESA are guidance documents, not mandatory regulatory documents. However, the ESA envisions Recovery plans as the central organizing tool for guiding the recovery of listed species. Recovery plans also guide federal agencies in fulfilling their obligations under Section 7(a)(1) of the ESA, which calls on all federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species." In addition to outlining proactive measures to achieve species recovery, Recovery plans provide a context and framework for other provisions of the ESA with respect to federally listed species, including but not limited to consultations on federal agency activities under Section 7(a)(2) and the development of Habitat Conservation Plans in accordance with Section 10(a)(1)(B).

This Recovery Plan serves as a guideline for achieving recovery goals by describing the criteria by which NMFS would measure species recovery, the strategy to achieve recovery, and the recommended recovery actions necessary to achieve viable populations of steelhead within the SCCCS Recovery Planning Area.

Environmental Setting

The SCCCS Recovery Planning Area is dominated by a series of steep mountain range and coastal valleys and terraces. Watersheds within the region fall into two basic types: those characterized by short coastal streams draining mountain ranges immediately adjacent to the coast (*e.g.*, Santa Cruz and Santa Lucia Mountains), and those watersheds containing larger river systems that extend inland through gaps in the coastal ranges (*e.g.*, Pajaro and Salinas Rivers, and Arroyo Grande Creek).

The SCCCS Recovery Planning Area has a Mediterranean climate, with long dry summers and brief winters with short, sometimes intense cyclonic winter storms. Rainfall is restricted almost exclusively to the late fall, winter, and early spring months (November through May). Additionally, there is a wide disparity between winter rainfall from north to south, as well as between coastal plains and inland mountainous areas. Snow accumulation is generally small and of short duration, and does not typically contribute significantly to peak run-off in South-Central California watersheds. The SCCCS Recovery Planning Area is also subject to an El Niño/La Niña weather cycle that can significantly affect winter precipitation, causing highly variable rainfall and significant changes in oceanic conditions.

Base flows (average dry-season flows) in South-Central California watersheds are strongly influenced by groundwater which is transported to the surface through faults and fractured rock formations. Many rivers and streams in this region naturally exhibit interrupted base flow patterns (*i.e.,* alternating reaches with perennial and seasonal surface flow) controlled by geologic formations, and the strongly seasonal precipitation pattern characteristic of a Mediterranean climate. Water temperatures are generally highest during summer months, but can be locally cooled by springs, seeps, and rising groundwater, creating refugia where conditions remain suitable for rearing salmonids, even during the summer.

Significant portions of the upper watersheds within the SCCCS Recovery Planning Area are contained within the Los Padres National Forest (Monterey and Santa Lucia Ranger Districts). These forests are managed primarily for water production, recreation, and protection of native

fish, wildlife, and botanical resources (with limited cattle grazing).

Urban development is concentrated in coastal areas and inland valleys, with the most extensive and densest urban development located within the Pajaro Salinas, San Luis Obispo and Arroyo Grande watersheds. The SCCCS Recovery Planning Area is home to more than 2.8 million people. Some coastal valleys and foothills are extensively developed with agriculture - principally row-crops, orchards, and vineyards (*e.g.,* Pajaro, Salinas and Arroyo Grande valleys).

Recovery Goals and Viability Criteria

The overarching goal of this Recovery Plan is recovery of the SCCCS DPS and its removal from the Federal List of Endangered and Threatened Wildlife (50 C.F.R. 17.11). To achieve this goal, the ESA requires that Recovery plans, to the maximum extent practical, incorporate objective, measurable criteria that, when met, would result in a determination in accordance with the provisions of the ESA that the species be delisted (50 CFR 17.11 and 17.12).

Recovery criteria are built upon viability criteria developed by NMFS's Technical Recovery Team (TRT) for the individual anadromous *O. mykiss* populations and the DPS as a whole. A ***viable population*** is defined as a population having a negligible risk (< 5%) of extinction due to threats from demographic variation, natural environmental variation, and genetic diversity changes over a 100-year time frame. A ***viable DPS*** is comprised of a sufficient number of viable populations spatially dispersed, but proximate enough to maintain long-term (1,000-year) persistence and evolutionary potential (McElhany *et al*. 2000). The viability criteria are intended to describe characteristics of the species, within its natural environment, necessary for both individual populations and the SCCCS DPS as a whole to be viable, *i.e.,* persist over a specific period of time, regardless of other ongoing effects caused by human actions.

Recovery of the threatened SCCCS DPS will require recovery of a minimum number of viable populations within each of four Biogeographic Population 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 species, and thus the long-term viability of the SCCCS DPS. Each population must exhibit a set of biological characteristics (*e.g.,* minimum mean annual run size, persistence over variable oceanic conditions, spawner density, anadromous fraction, *etc*.) in order to be considered viable. (Boughton *et al.* 2007b).

Recovery Strategy

Recovery of South-Central California steelhead will require effective implementation, as well as a scientifically based biological, recovery strategy. The framework for a durable implementation strategy involves two key principles: 1) solutions that focus on fundamental causes for watershed and river degradation, rather than short-term remedies; and 2) solutions that emphasize resilience in the face of projected climate change to ensure a sustainable future for both human communities and steelhead (Beechie *et al*. 2010, 1999; Boughton 2010a, Naiman 2005, Lubchenco 1998). Such a strategy:

- Looks for opportunities for sustainable water and land-use practices;
- Restores river and estuary processes that naturally sustain steelhead habitats;
- Provides diverse opportunities for steelhead within the natural range of ecological adaptability;
- Sustains ecosystem services for humans by reinforcing natural capital and the self-maintenance of watersheds and river systems; and
- Builds natural and societal adaptive capacity to deal with climate change.

A comprehensive strategic framework is necessary to serve as a guide to integrate the actions contributing to the goal of recovery of the SCCCS DPS. This strategic framework incorporates the concepts of viability at both the population and DPS levels, and the identification of threats and recovery actions for each of the four BPGs.

NMFS has identified core populations intended to serve as the foundation for the recovery of the species in the SCCS Recovery Planning Area. Threats assessments for the species indicate that recovery actions related to the modification of existing fish passage barriers and changes in water storage and management regimes within certain rivers of the SCCCS Recovery Planning Area are essential to the recovery of the species. Extensive, high quality habitat exists above a large number of passage barriers in these river systems. These areas are currently not included within the SCCCS DPS as defined in the listing rule (71 FR 834). However, because these habitat areas comprise a majority of the prime steelhead spawning and rearing habitat within the species' natural range, they are a major focus of recovery actions.

Uncertainties remain regarding the level of recovery necessary to achieve population and DPS viability, therefore, additional research and monitoring of *O. mykiss* populations within the SCCCS Recovery Planning Area is an essential component of this Recovery Plan. As the Recovery Plan is implemented, additional information will become available to: (1) refine the viability criteria; (2) update and refine the threats assessment and related recovery actions; (3) determine whether individual threats have been abated or new threats have arisen; and (4) evaluate the overall viability of anadromous *O. mykiss* in the SCCCS Recovery Planning Area. Additionally, there will be a review of the recovery actions implemented and population and habitat responses to these actions during the 5-year status reviews of the DPS.

Recovery Actions

Many complex and inter-related biological, economic, social, and technological issues must be addressed in order to recover anadromous *O. mykiss* in the SCCCS DPS. Policy changes at the federal, state and local levels will likely be necessary to implement many of the recovery actions identified in this Recovery Plan. For example, without substantial strides in water conservation, efficiency, and re-use throughout South-Central California, flow conditions for anadromous salmonids will limit recovery. Similarly, recovery is unlikely without programs to restore properly functioning historic habitats such as estuaries, and access to upstream spawning and rearing habitat.

Many of the recovery actions identified in this Recovery Plan also address watershed-wide processes (*e.g.*, wild-fire cycle, erosion and sedimentation, runoff and waste discharges) which will benefit a wide variety of native species (including other state and federally listed species, or species of special concern) by restoring natural ecosystem functions. Some of the listed species which co-occupy coastal watersheds with South-Central California steelhead include: Tidewater goby, Foothill yellow-legged frog, California least tern, California red-legged frog, Southwestern pond turtle, Arroyo toad, Least Bell's Vireo. Additionally, Pacific lamprey, another anadromous species occupying South-Central California watersheds, and whose numbers have declined significantly, can also be expected to benefit from many of the recovery actions identified in this Recovery Plan.

Restoration of steelhead habitats in coastal watersheds will also provide substantial benefits for human communities. These include, but are not limited to, improving and protecting the water quality of important surface and groundwater supplies, reducing damage from periodic flooding resulting from floodplain development, and controlling invasive exotic animal and plant species which can threaten water supplies and increase flooding risks.

Restoring and maintaining ecologically functional watersheds also enhances important human uses of aquatic habitats occupied by steelhead; these include activities such as outdoor recreation, environmental education (at primary and secondary levels), field-based research of both physical and biological processes of coastal watersheds, aesthetic benefits, and the preservation of tribal and cultural heritage values.

The final category of benefits accruing to recovered salmon and steelhead populations involve the ongoing costs associated with maintaining populations that are at risk of extinction. Significant resources are spent annually by federal, state, local, and private entities to comply with the regulatory obligations that accompany species that are listed under the ESA. Important activities, such as water management for agriculture and urban uses, can be constrained to protect ESA listed species. As a result of these ESA related obligations, such as compliance with Section 7 requirements, the take prohibitions of Section 9, and the development of Section 10 Habitat Conservation Plans, a degree of uncertainty is often experienced by regulated entities. Recovering listed salmonid species will reduce the regulatory obligations imposed by the ESA, and allow land and water managers greater flexibility to optimize their activities, and reduce costs related to ESA protections.

Although the recovery of South-Central California steelhead is expected to be a long process, the TRT recommended certain actions that should be implemented as soon as possible to help facilitate the recovery process for the SCCCS DPS. These include identifying a set of core populations on which to focus recovery efforts, protecting extant parts of inland populations, identifying refugia habitats, protecting and restoring estuaries, and collecting population data (Boughton *et al.* 2007b). Recovery actions for individual watersheds are identified in separate chapters covering the five BPGs within the SCCCS Recovery Planning Area (see Chapters 9-12).

Implementation and Recovery Action Cost Estimates

Implementation of this Recovery Plan will require a shift in societal attitudes, understanding, priorities, and practices. Many of the current land and water use practices that are detrimental to steelhead (particularly water supply and flood control programs) are not sustainable. Modification of these practices is necessary to both continue to meet the needs of the human communities of South-Central California and restore the habitats upon which viable steelhead populations depend.

Since the listing of South-Central California steelhead as threatened in 1997, efforts have accelerated to change many unsustainable water and land-use practices; however a great deal more needs to be done before steelhead are recovered and ultimately removed from the list of federally endangered or threatened species.

Investment in the recovery of South-Central California steelhead will provide economic and societal as well as environmental benefits. Monetary investments in watershed restoration projects can benefit the economy in multiple ways. These include stimulating the economy directly through the employment of workers, contractors and consultants, and the expenditure of wages and restoration dollars for the purchase of goods and services. Habitat restoration projects have been found to stimulate job creation at a level comparable to traditional infrastructure investments such as mass transit, roads, or water projects (Sunderstrom *et al.* 2011, Nielsen-Pincus and Moseley 2010, Meyer Resources Inc., 1988). In addition, viable salmonid populations provide ongoing direct and indirect economic benefits as a natural resource base for angling, outdoor recreation, and tourist related activities. Dollars spent on steelhead recovery have the potential to generate significant new dollars for local, state, federal and tribal economies.

Perhaps the largest direct economic returns resulting from recovered anadromous salmonids are associated with angling. On average 1.6 million anglers fish the Pacific region annually (Oregon, Washington and California) and 6 million fishing trips were taken annually between 2004 and 2006 (National Marine Fisheries Service 2010b). Most of these trips were taken in California and most of the anglers live in California. Projections of the economic and jobs impacts of restored salmon and steelhead fisheries for California have been estimated from $118 million to $5 billion dollars, and supporting thousands of jobs (Michael 2010, Southwick Associates 2009; see also, Meyer Resources, Inc. 1988).

Estimating total cost to recovery in the SCCS Recovery Planning Area is challenging for a variety of reasons. These include the need to 1) refine recovery criteria; 2) complete investigations such as barrier inventories and assessments, and habitat typing surveys in the core populations; 3) identify flow regimes for individual watersheds; and 4) develop site-specific designs and plans to carry out individual recovery actions. Additionally, the biological response of steelhead to many of the recovery actions is uncertain and will require extensive monitoring. The recovery action tables (Tables 9-4 through 13-13) for each BPG within the SCCCS Recovery Planning Area includes a preliminary estimate of the costs of individual recovery actions, based on the general recovery action descriptions contained in Chapter 8, Summary of DPS-Wide Recovery Actions, Table 8.2 (Recovery Actions Glossary).

Costs estimates have been provided wherever possible, but in some cases where the uncertainties regarding the exact nature of the recovery actions is unknown (*e.g.*, complete barrier removal versus modification), these costs estimates can only be provided after site-specific investigations are completed. Estimating the total cost to recovery is further complicated because achieving recovery will be a long-term effort, involving multiple decades. Based upon the costs of individual recovery actions identified, NMFS estimates that the cost of implementing recovery actions throughout the SCCCS Recovery Planning Area will be approximately 560 million dollars over the next 80 to 100 years. Appendix E (Estimated Costs of Recovery Actions) of the Recovery Plan contains estimates for categories of typical watershed restoration activities.

Many of the recovery actions identified in the recovery action tables are intended to restore basic ecosystem processes and functions. As a result, many of these recovery actions will be, or already have been, initiated by local, state and federal agencies, as well as non-governmental organizations and other private entities as a part of their local or regional environmental protection efforts. Recovery actions may be eligible for funding from multiple funding sources at the federal, state, and local levels. Many of these grant programs also offer technical assistance, including project planning, design, permitting, and monitoring. Regional personnel with NMFS, California Department of Fish and Game, and the U.S. Fish and Wildlife Service can also provide assistance and current information on the status of individual grant programs. Appendix E provides a list of federal, state, and local funding sources. In weighing the costs and benefits of recovery, the multiple long-term benefits derived from short-term costs must be considered in any assessment. South-Central California steelhead recovery should therefore be viewed as an opportunity to diversify and strengthen the regional economy while enhancing the quality of life for present and future generations.

Recovery Partners

Recovery of South-Central California steelhead depends most fundamentally on a shared vision of the future. Such a vision would include a set of rehabilitated watersheds, rivers, and estuaries which support steelhead and other native species over the long-term, efficiently sustain ecological services for people, and allow river systems to respond to climate change.

A shared vision for the future can align interests and encourage cooperation that, in turn, has the potential to improve rather than undermine the adaptive capacity of public resources such as functioning watersheds and river systems.

The construction of a shared vision for South-Central California steelhead will require a number of basic institutional arrangements: 1) a deliberative forum (or set of forums) where interested stakeholders, including non-governmental organizations, can share experiences and ideas; 2) information networks that allow stakeholders to disseminate information with a broad array of interested and effected parties; and 3) the development and maintenance of trust and reciprocity that allows meaningful deliberation on inherently complex and contentious issues.

Technical Recovery Team Members – Pajaro River 2006

Achieving recovery of South-Central California steelhead will also require a number of coordinated activities, including implementation of strategic and threat-specific recovery actions, monitoring of the existing population's response to recovery actions, and further research into the diverse life history patterns and adaptations of *O. mykiss* to a semi-arid and highly dynamic environment (including the ecological relationship between anadromous and non-anadromous life history patterns).

Effective implementation of recovery actions will entail: 1) development of cooperative relationships with private land owners, non-governmental organizations, special districts, and local governments with direct control and responsibilities over non-federal land-use practices to maximize recovery opportunities; 2) participation in the land use and water planning and regulatory processes of local, regional, state, and federal agencies to integrate recovery efforts into the full range of land and water use planning; 3) close cooperation with state resource agencies such as the California Department of Fish and Game, California Coastal Commission, CalTrans, California Department of Parks and Recreation, State Water Resources Control Board, and Regional Water Quality Control Boards, and University Cooperative Extension to ensure consistency of recovery efforts; and 4) partnering with federal resource agencies, including the U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, U.S. Bureau of Reclamation, U.S. Bureau of Land Management, U.S. Army Corps of Engineers, U.S. Department of Transportation, U.S. Department of Defense, and the U.S. Environmental Protection Agency, ad U.S. Natural Resource Conservation Service.

NMFS intends to promote the Recovery Plan and provide needed technical information and assistance to entities responsible for activities that may impact the species' recovery, including implementation of high priority recovery actions. Additionally it will be important to work with cities and counties to incorporate protective measures consistent with recovery objectives in their General Plans and Local Coastal Plans. NMFS also intends to work with state and federal regional entities on regional planning efforts such U.S. Forest Service Land Resource Management Plans, State Park General Plans, Regional Water Control Board Basin Plans, and Local Coastal Plans.

Estimated Time to Recovery and Delisting

Given the scope and complexity of the threats and recovery actions identified within the SCCS Recovery Planning, the time to full recovery can be provisionally estimated to vary from 80 to 100 years. Delays in the completion of recovery

actions, time for habitats to respond to recovery actions, or the species' response to recovery actions would lengthen the time to recovery. A modification of the provisional population or DPS viability criteria resulting in smaller run-sizes, or the number or distribution of recovered populations, could shorten the time to recovery.

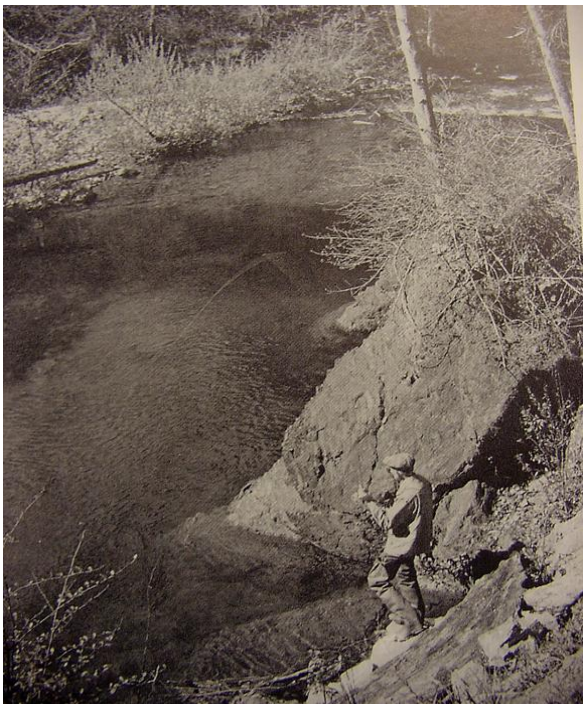
1. Introduction

"And so little rivers, granted sufficient rainfall to give them life, possess one thing in common. These sturdy migrants forge swiftly and surely over the tidal bars and up the current perhaps a dozen or two-score miles to the spawning bars at the headwaters far back in a deep dark canyon of the Coast Range. . . . Were I to conduct a visiting angler on a tour of these charming southern streams, I should like to first take him up to the Big Sur in the giant redwoods, where the rushing river comes downs through the forest from its birthplace far back in the mysterious shrouded canyons of the great Santa Lucia Range."

Claude M. Kreider. Steelhead.
G.P. Putnam's Sons, New York. 1948

1.1 South-Central California Coast Steelhead at Risk

Steelhead are the anadromous, or ocean-going, form of the species *Oncorhynchus mykiss.* Historically, these fish were the only abundant salmonid species that occurred naturally within the coast ranges of South-Central California (Jordan and Evermann 1896, 1923, Jordan and Gilbert 1881). Steelhead entered the rivers and streams draining the Coast Ranges from Point Sal to the U.S. Mexican Border during the winter and spring, when storms produced sufficient runoff to breach the sandbars at the rivers' mouths and provided fish passage to upstream spawning and rearing habitats. These fish and their progeny were sought out by recreational anglers during the winter, spring and summer fishing seasons (Alagona *et al*. 2011, Swift *et al.* 1993, Nehlsen, *et al.*, 1991, Shapovalov *et al.* 1981, Capelli 1974, Boydstun 1973, Fry 1973, 1938, Combs 1972, Shapovalov and Taft 1954, Kreider 1948, Hubbs 1946, Snyder 1913). The ethnographic and archaeological evidence regarding the role of *O. mykiss* in Native American culture is currently limited and subject to varying interpretation by investigators (Hosale 2010, Lightfoot and Parrish, Glassow *et al*. 2007, Gobalet *et al.*, 2004, Hildebrandt 2004, Hudson and Blackburn 1982, Horne 1981, Swezey and Heizer 1977, Spanne 1975, Tainter 1975).



Steelhead Angler, Big Sur River. c. 1940s.

Following the dramatic rise in South-Central California's human population after World War II and the associated land and water

development within coastal drainages (particularly major dams and water diversions), steelhead abundance rapidly declined, leading to the extirpation of populations in many watersheds and leaving only sporadic and remnant populations in the remainder (Boughton *et al.* 2005, Good *et al.* 2005, Helmbrecht and Boughton 2005, Busby *et al.* 1996). While the steelhead populations declined sharply, most coastal watersheds retained populations of the non-anadromous life history form of the species (commonly known as resident or rainbow trout), often in the upper reaches of watersheds within national forest lands that were more protected from the impacts of human development. In response to the dwindling native populations of anadromous and related non-anadromous resident *O. mykiss*, and in an effort to meet the burgeoning demand for recreational fishing opportunities, the California Department of Fish and Game expanded an extensive put-and-take stocking program (Dill *et al*. 1997, Leitritz 1970, Butler and Borgeson 1965). This program was aimed principally at recreational anglers, and not intended or expected to address the underlying causes of the decline of the anadromous runs in South-Central California. As conditions in South-Central California coastal rivers and stream continued to deteriorate, put-and-take trout stocking became more focused on suitable manmade reservoirs.

Since the listing of South-Central California Coast steelhead as threatened in 1997, the California Department of Fish and Game has ceased stocking hatchery reared fish in the anadromous waters of South-Central California (California Department of Fish and Game and U.S. Fish and Wildlife Service 2010). However, a substantial portion of the upper watersheds, which contain the majority of historical spawning and rearing habitats for anadromous *O. mykiss*, remain intact (though inaccessible to anadromous fish) and protected from intensive development as a result of their inclusion in the Los Padres National Forest. Additionally, a significant amount of land within South-Central California coastal watersheds is protected by inclusion within regional parks and various military installations, including the upper Salinas watershed (including portions of Nacimiento and San Antonio Rivers) within the U.S. Army's Camp Roberts and Fort Hunter Liggett.

Juvenile Steelhead, Carmel River, 1907.

The National Marine Fisheries Service's (NMFS) responsibility and goal is to prevent the extinction of steelhead in the wild and ensure the long-term persistence of self-sustaining, and ultimately harvestable, wild populations of steelhead within the SCCCS DPS by addressing those factors limiting the species' ability to survive and reproduce in the wild. The species can be removed from the list of federally-protected threatened and endangered species only after this goal has been reached.

Recovery of steelhead will require reducing threats to the long-term persistence of wild populations, maintaining multiple interconnected populations of steelhead across the diverse habitats of their native range, and preserving the diversity of steelhead life history strategies that allow the species to withstand natural environmental variability—both intra-annually and over the long-term.

An effective steelhead recovery program will require the implementation of a series of coordinated recovery actions that:

- ❑ Prevent steelhead extinction by protecting existing populations and their habitats.
- ❑ Maintain current distribution of steelhead and restore distribution to

previously occupied areas that are essential for recovery.

- Increase abundance of steelhead to viable population levels, including the expression of all life history forms and strategies.
- Conserve existing genetic diversity and provide opportunities for natural interchange of genetic material between and within metapopulations.
- Maintain and restore suitable habitat conditions and characteristics for all life history stages so that viable populations can be sustained naturally.
- Refine and demonstrate attainment of recovery criteria through research and monitoring.

Preventing the extinction of steelhead has long term implications for all *O. mykiss* populations (Boughton *et al.* 2007b, 2006). Steelhead have evolved an ability to search out and use a wide variety of ever-changing habitats over millennia. The loss of steelhead would initiate a process of irreversible cumulative extinctions of other native *O. mykiss* trout populations in the region because the evolutionary innovations that are the product of anadromy could no longer be naturally transmitted among the remaining resident *O. mykiss* populations. Because of the naturally dynamic and unstable environment of South-Central California, the remaining resident *O. mykiss* populations would likely continue on the path of gradual differentiation and perhaps even speciation (Hoelzer *et al*. 2008), but with a vastly reduced ability to innovate and survive in a changing environment., thus increasing their chance of extirpation.

1.2 South-Central California Coast Steelhead Listing History

After NMFS completed a comprehensive status review of all West Coast steelhead populations (Busby *et al.* 1996), SCCCS populations were proposed for listing by NMFS as an threatened Evolutionarily Significant Unit (ESU) on August 9, 1996 (61 FR 56138). An ESU is composed of a group of conspecific populations that are substantially reproductively–isolated from other conspecific populations, and that possess important elements of the evolutionary legacy of the species which are expressed genetically and phenotypically that have adaptive value (56 FR 224, Waples 1998, 1995, 1991a, 1991b). The South-Central Coast Steelhead ESU was formally listed as threatened on August 18, 1997 (62 FR 43937). The original ESU boundaries during the first listing of 1997 were from the Pajaro River (Monterey County) south to (but not including) the Santa Maria River (San Luis Obispo County). During the time between the initial listing and a subsequent re-listing in 2006, NMFS adopted the DPS designation for steelhead to replace the ESU designation to be consistent with the listing policies and practices of the U. S. Fish and Wildlife Service. A DPS designation (61 FR 4722) uses similar but slightly different criteria from the ESU designation for determining when a group of organisms constitutes a DPS under the Endangered Species Act (ESA). A DPS is a population or group of populations that is discrete from other populations of the same taxon, and significant to its taxon. A group of organisms is discrete if it is "markedly separated from other populations of the same taxon as a consequence of physical, physiological, ecological, and behavioral factors.'' While a group of organisms is discrete if it is "markedly separated from other populations of the same taxon" it does not have to exhibit reproductive isolation under the DPS designation.

Following a subsequent status review of West Coast steelhead populations in 2005 (Good *et al.* 2005), a final listing determination for the threatened SCCCS DPS was issued on January 5, 2006 (71 FR 834).

The final designation for the SCCCS DPS encompasses all naturally spawned steelhead between the Santa Maria River (inclusive) and the U.S.-Mexico border. Consequently, this DPS includes only those *O. mykiss* whose freshwater habitat occurs below impassible barriers, whether artificial or natural, and which exhibit an anadromous life history. Individuals that have originated in freshwater above impassable barriers and exhibit an anadromous life history are also considered as part of the DPS when they are within waters below the most downstream impassable barriers.

1.3 Designated Critical Habitat

The ESA requires NMFS to designate critical habitat for all listed species. Critical habitat is defined as specific areas where physical or biological features essential to the conservation (recovery) of the species exist and may require special management considerations or protection. For recovery planning and implementation purposes, these physical or biological features can be viewed as the set of habitat characteristics or conditions that are the end goal of many recovery actions.

When designating critical habitat, NMFS considers certain habitat features called "Primary Constituent Elements" (PCEs) that are essential to support one or more life history stage(s) of the listed species (50 CFR 424.12b). PCEs considered essential for the conservation of the SCCCS DPS are those sites and habitat components that support one or more life stages and contain physical or biological features essential to survival, growth, and reproduction. These PCEs include:

- **Freshwater spawning sites** with sufficient water quantity and quality as well as adequate substrate (*i.e.*, spawning gravels of appropriate sizes) to support spawning, incubation and development.
- **Freshwater rearing sites** with sufficient water quantity and floodplain connectivity to form and maintain physical habitat conditions and allow development and mobility; sufficient water quality to support growth and development; food and nutrient resources such as terrestrial and aquatic invertebrates and forage fish; and natural cover such as shade, submerged and overhanging large wood, log jams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
- **Freshwater migration corridors** free of obstruction and excessive risk of predation with adequate water quantity to allow for juvenile and adult mobility; cover, shelter, and holding areas for juveniles and adults; and adequate water quality to allow for survival.
- **Estuarine areas** that provide uncontaminated water and substrates; food and nutrient sources to support growth and development; and connected shallow water areas and wetlands to conceal and shelter juveniles. Estuarine areas include coastal lagoons that are seasonally stable, predominantly freshwater-flooded habitats that remain disconnected from the marine environment except during high streamflow events, and tidally-influenced estuaries that provide a dynamic shallow water environment.

- **Marine areas** with sufficient water quality to support growth, development and mobility; food and nutrient resources such as marine invertebrates and forage fish; and nearshore marine habitats with adequate depth, cover and marine vegetation to provide shelter.

The final critical habitat designation for the SCCCS DPS was issued on September 2, 2005 (70 FR 52488). A total of 1,240 miles of stream habitat and 3 square miles of estuarine habitat were designated as critical habitat from the 28 watersheds within the range of this DPS. Critical habitat for the SCCCS DPS includes most, but not all, occupied habitat from the Pajaro River in Monterey County to Arroyo Grande Creek in southern San Luis Obispo County, but excludes some occupied habitat based on economic considerations and all military lands with occupied habitat. The stream channels with designated critical habitat are listed in 70 FR 52488. A review of the current critical habitat designations may result in modifications of the current critical habitat designations, including the addition of unoccupied habitat which exhibit PCEs.

1.4 The Recovery Planning Process

The ESA, as amended (16 U.S.C. 1531 *et seq.*), mandates that NMFS develop and implement recovery plans for the conservation of listed species. The SCCCS DPS was listed as threatened in 1997 under the ESA. The development and implementation of a Recovery Plan for the SCCCS DPS is considered vital to the continued persistence and recovery of steelhead in this region.

NMFS has established a South-Central California Coast Steelhead Recovery Planning Area for the purposes of developing this Recovery Plan and guiding the implementation of actions to recover this species. The SCCCS Recovery Planning Area extends from the Santa Maria River south to the Tijuana River at the U.S.-Mexico border and includes those portions of coastal watersheds that are at least seasonally accessible to steelhead entering from the ocean and the upstream portions of some watersheds that are currently inaccessible to steelhead due to man-made barriers. NMFS' Southwest Region (SWR) Protected Resources Division (PRD) in Long Beach, California is responsible for the development of the recovery plan for the SCCCS DPS.

The Recovery Plan serves as a guideline for achieving recovery goals by describing the biological criteria that the listed species (and individual populations) must exhibit, and the recovery actions that must be taken to meet these criteria. Although recovery plans provide guidance, they are not regulatory documents. However, the ESA envisions recovery plans as the central organizing tool for guiding the recovery of listed species. Recovery plans also provide guidance to federal agencies fulfilling their obligations under Section 7(a)(1) of the ESA, which calls on all federal agencies to "utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species . . .". In addition to outlining proactive measures to achieve species recovery, recovery plans provide a context and framework for implementing other provisions of the ESA, including consultations on federal agency activities under Section 7(a)(2) and the development of Habitat Conservation Plans (HCPs) in accordance with Section 10(a)(1)(B).

Recovery plans are also intended to be used to inform local, state, tribal and non-governmental entities and individuals who may wish to participate in the conservation and recovery of the species, or who are engaged in activities that may adversely affect that species. Successful implementation of a recovery plan depends upon the cooperation of stakeholders and planning and regulatory entities.

Pursuant to Section 4(f) of the ESA, a recovery plan must be developed and implemented for

species listed as threatened or endangered, unless it is found that such a plan will not promote the conservation of the species. A recovery plan must include the following:

- Objective, measurable criteria, which, when met, will allow delisting of the species (see Chapter 6, Steelhead Recovery Goals, Objectives & Criteria);
- A description of site-specific management actions necessary for recovery (see Chapters 9 through 13, Biogeographic Population Groups); and
- Estimates of the time and cost to carry out the recommended recovery measure (see Chapters 9 through 13, Biogeographic Population Groups, Recovery Action Tables).

Past recovery plans for other listed species have generally focused on the abundance, productivity, habitat, and other life history characteristics of a species. While knowledge of these characteristics is important for making sound conservation management decisions, the long-term sustainability of a threatened or endangered species can only be ensured by alleviating the threats that are contributing to the decline of that species or impeding its recovery. Therefore, the identification of such threats is a key component of any recovery program (National Marine Fisheries Service 2010a).

The Interim Endangered and Threatened Species Recovery Planning Guidance document (National Marine Fisheries Service 2010a) recommends "*…using a threats assessment for species with multiple threats to help identify the relative importance of each threat to the species' status, and, therefore, to prioritize recovery actions in a manner most likely to be effective for the species' recovery*." This Recovery Plan uses this recommended approach to identify and prioritize threats to the SCCCS DPS. The prioritized threats are then used to guide the identification of specific recovery actions. Chapter 4, Current DPS-Level Threats Assessment, summarizes the threats across the DPS and Chapters 9 through 13 provide a summary of the threats assessments within each of the five BPGs of the DPS. The threats assessment methodology is discussed in Appendix D, South-Central California Coast Steelhead Recovery Planning Area Threats Assessment (CAP Workbooks) Methodology.

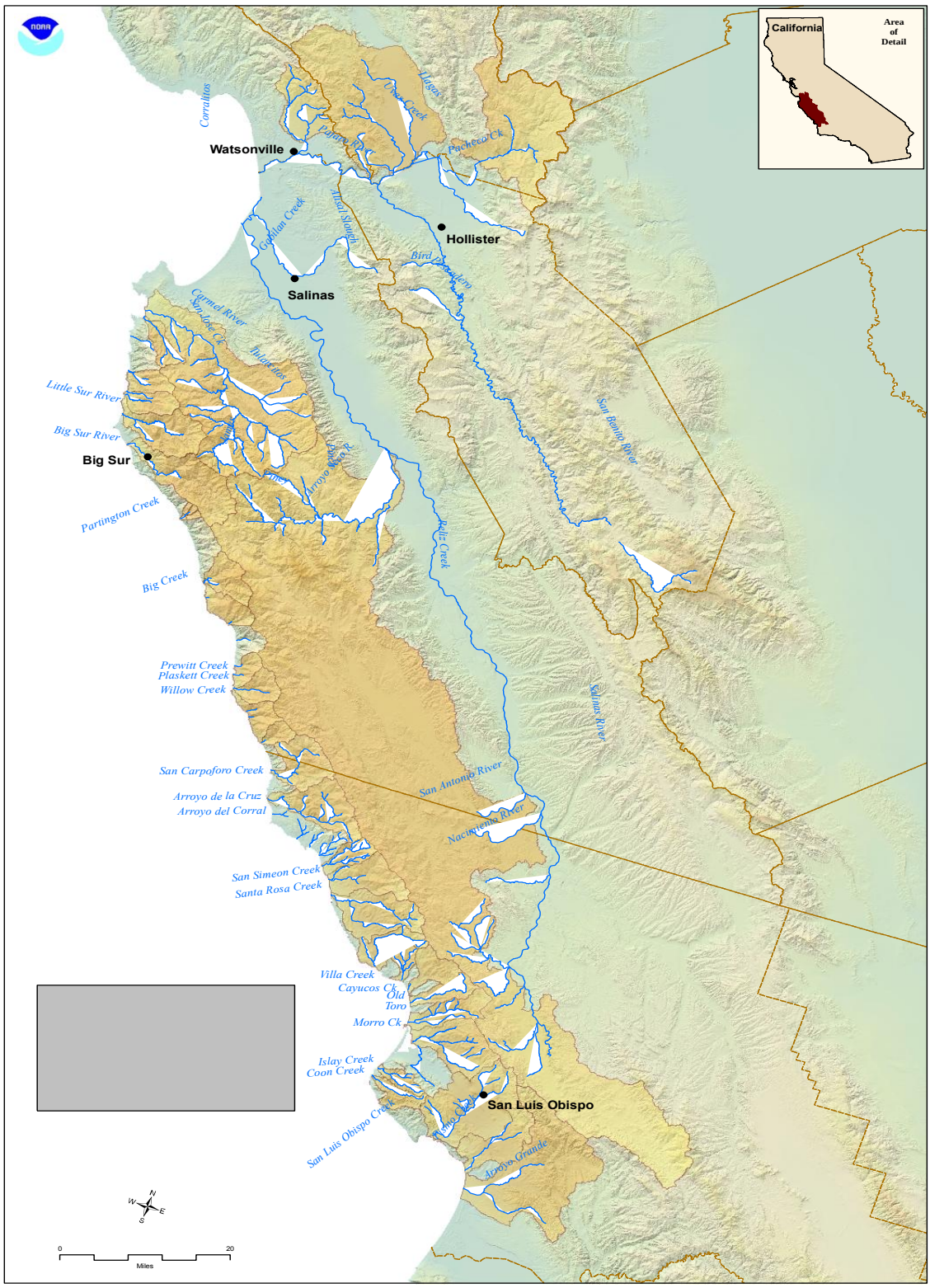


Figure 1-1. South-Central California Coast Steelhead Recovery Planning Area. Boundaries of Recovery Planning Area extend beyond the current distribution of the listed species

1.4.1 South-Central/Southern California Steelhead Technical Recovery Team

As part of its recovery planning efforts, NMFS Southwest Region (SWR) assembled a team of scientists with a wide variety of expertise in biological and physical sciences to provide technical assistance to the recovery planning process for South-Central California Coast steelhead; this group is known as the Technical Recovery Team (TRT). NMFS' intent in establishing the TRT was to seek geographic and species-specific expertise to develop a scientific foundation for the recovery planning. The TRT produced and published a number of Technical Memoranda, which provide a description of the unimpaired historic populations within the Recovery Planning Area (Boughton *et al.* 2006), and identified viability criteria for anadromous *O. mykiss* in the SCCCS DPS (Boughton *et al*. 2007b). Additionally, NMFS's Southwest Science Center produced and published a number of additional Technical Memoranda dealing with potential over-summering habitat in the region (Boughton and Goslin 2006), the reduction of the South-Central range limit of anadromous *O. mykiss* (Boughton *et al*. 2005), research and monitoring (Boughton 2010b), and recovery strategies in a changing environment (Boughton 2010a). Finally, NMFS's Southwest Science Center undertook a number of genetic investigations in an attempt to identify the population structure of the SCCCS DPS, and provided scientific review of local and regional recovery efforts (Clemento *et al.* 2009, Pearse and Garza 2008, Girman and Garza 2006; see also, Nielsen *et al*. 2001, 1994c).

1.4.2 Public Participation

Local, state, and federal support of recovery planning by those whose activities directly affect the listed species, and whose actions will be most affected by recovery requirements, is essential to the successful implementation of any recovery plan. NMFS supports and participates in collaborative efforts to develop and implement recovery plans by engaging local communities, state and federal entities, and other stakeholders.

As part of the recovery planning process, NMFS published a notice of intent to prepare a Recovery Plan for the species in the Federal Register and conducted a series of Recovery Planning Workshops to solicit information on threats and recovery actions as part of the development of the Recovery Plan for the SCCCS DPS. Public workshops were held in Arroyo Grande and Carmel, California in April 2007, and in San Luis Obispo and Carmel, California in June 2007.

At these workshops, NMFS provided a general overview of the:

- federal recovery planning process;
- preliminary timeline for NMFS Recovery Plan development;
- current understanding of steelhead populations and their habitats;
- threats assessment process and the threats identified by NMFS; and

NMFS also received public input on potential recovery actions.

Following the overview, workshop participants were separated into smaller, facilitated breakout groups to identify threats to specific steelhead populations and their habitats. In the final set of workshops, breakout groups identified potential recovery actions for specific populations and habitats. Information obtained from these

workshops was used in the development of a formal threats assessment analysis using The Nature Conservancy's Conservation Action Planning (CAP) threats assessment methodology, and the identification of a full suite of recovery actions based on those threats. See Appendix D, South-Central California Coast Steelhead Recovery Planning Area Threats Assessment (CAP) Workbook Methodology.

NMFS has also established a web page to provide ongoing updates and information to the public about the recovery planning process, access to Recovery Plan materials and implementation of recovery actions. The home web page for NMFS SWR salmonid recovery planning is accessible at: http://swr.nmfs.noaa.gov/recovery/index.htm. The web page for recovery planning and implementation for the SCCCS DPS (including the Recovery Plan, related NOAA Technical Memorandum, and Threats Assessment summaries) can be found at: http://swr.nmfs.noaa.gov/recovery/So_Cal.htm.

Finally, recovery of the species cannot occur without public involvement in the implementation process. NMFS encourages the efforts of watershed groups dedicated to improving watershed ecosystem conditions. NMFS believes it is critically important to base steelhead recovery efforts on the many federal, state, regional, local, and private conservation efforts already underway throughout the region. Local support of the Recovery Plan by those whose activities directly affect the listed species, and whose actions will be most affected by recovery efforts, is essential. NMFS therefore supports and participates in locally-led collaborative efforts to develop projects and plans, involving local communities, state and federal entities, and other stakeholders. NMFS anticipates that watershed groups and private entities can utilize the information and recommendations provided in this Recovery Plan to further refine and develop recovery actions to abate threats and meet recovery objectives.

2. Steelhead Biology and Ecology

"[W]e must constantly keep in mind that variation, i.e., deviation from the norm, is one of the most marked characteristics of animal life. And of the vertebrates, the trout are among the most variable of all. Further, of the trout the steelhead is one of the most variable forms. . . . As an example, in the coastal streams most fish migrate in their first year, third, fourth, or fifth years, or do not migrate at all."

Leo Shapovalov and Alan C. Taft,
Life Histories of Steelhead Trout and Silver Salmon, 1954

2.1 SPECIES TAXONOMY AND LIFE HISTORY

Oncorhynchus mykiss is one of six Pacific salmon in the genus *Oncorhynchus* that are native to the North American coast. O. *mykiss*, along with other species of Pacific salmon exhibit an anadromous life history, which means that juveniles of the species undergo a change that allows them to migrate to and mature in salt water before returning to their natal rivers or streams (*i.e.*, streams where they were spawned) to reproduce.

Two principal steelhead recovery objectives are to increase abundance of steelhead and to preserve the expression of their diverse life history strategies. A schematic illustration of the various life history strategies that occur in the SCCCS Recovery Planning Area is shown in Figure 2-1. The figure is best understood by tracing the various pathways a freshwater juvenile may follow. Those pathways may remain entirely within freshwater ecosystems or transition between freshwater, estuarine and marine ecosystems. The use of these different environments confers advantages or disadvantages to the survival and reproductive success of the individual depending on the conditions of those environments. Even though neighboring watersheds can differ, a viable population of steelhead may contain individuals expressing many, if not all, the diverse life history strategies exhibited by the species. See discussion below in Section 2.6, South-Central California Coast Steelhead Freshwater Life Cycle Habitat Use.

Steelhead are a highly migratory species. Adult steelhead (Figure 2-2) spawn in coastal watersheds; their progeny (Figure 2-3) rear in freshwater or estuarine habitats prior to migrating to the sea. Within this basic life history pattern, the species exhibits a greater variation in the time and location spent at each life history stage than other Pacific salmon within the genus *Oncorhynchus* (Hayes *et al*. 2011a, 2011b, Quinn 2005, Hendry *et al.* 2004).

The life cycle of steelhead generally involves rearing in freshwater for one to three years before migrating to the ocean and spending from one to four years maturing in the marine environment before returning to

spawn in freshwater. The ocean phase provides a reproductive advantage because individuals that feed and mature in the ocean grow substantially larger than freshwater residents, and larger females produce proportionately more eggs; however, the freshwater phase provides protected rearing environment, relatively free of competition and predators. This life history strategy is referred to as "fluvial-anadromous". Out-migration to the ocean (*i.e.,* emigration) usually occurs in the late winter and spring. In some watersheds, juveniles may rear in a lagoon or estuary for several weeks or months prior to entering the ocean. The timing of emigration is influenced by a variety of factors such as photoperiod, streamflow, temperature, and breaching of the sandbar at the river's mouth. These out-migrating juveniles, termed smolts (Figure 2.4), live and grow to maturity in the ocean for two to four years before returning to freshwater to reproduce (Jacobs *et al.* 2011, Borg 2010, Haro *et al*. 2009, Leder *et al.* 2006, Quinn 2005, Davies 1991, Groot and Margolis 1995, 1991, Northcote 1958).

The ocean phase of steelhead has not been studied extensively, though marine migration studies of other species of *Oncorhynchus* have encountered only isolated specimens of *O. mykiss* and as a result it is believed that the species does not generally congregate in large schools like other Pacific salmon of the genus *Oncorhynchus* (Grimes *et al*. 2007, Aydin *et al.* 2005, Burgner *et al*. 1992, 1980, Groot and Margolis 1991, Meyers *et al.* 1996, Hartt and Bell 1985). Consequently, the movement patterns of steelhead at sea are poorly understood. Some anadromous salmonids have been found in coastal waters relatively close to their natal rivers, while others may range widely in the North Pacific (Quinn 2005, Quinn and Myers 2005, Meyers *et al.* 1996, Groot and Margolis 1991, Burgner *et al*. 1992, 1980).

Returning adults may migrate from several to hundreds of miles upstream to reach their spawning grounds. The specific timing of spawning can vary by a month or more among streams within a region, occurring in winter and early spring, depending on factors such as run-off and sand bar breaching (Jacobs *et al.* 2011, Fukushima and Lesh 1998, Shapovalov and Taft 1954). Once they reach their spawning grounds, females use their caudal fin to excavate a nest (redd) in streambed gravels where they deposit their eggs. After fertilization by the male, the female covers the redd (often during construction of additional upstream redds) with a layer of gravel, where the embryos and alevins incubate within the gravel. Hatching time varies from about three weeks to two months depending on water temperature. The young fish emerge from the gravel two to six weeks after hatching. Adult steelhead do not necessarily die after spawning and may return to the ocean, sometimes repeating their spawning migration one or more times. It is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle *et al. 2008*, Moyle 2002). The frequency of repeat spawning among SCCCS DPS populations has not been investigated, and it is therefore unknown how it may differ from other populations, or the role repeat spawning plays in the population dynamics in South-Central California. Additional details regarding this species' life history can be found in Quinn (2005), Bjornn and Reiser (1991), Barnhart (1986, 1991), and Shapovalov and Taft (1954).

This species may also display a non-anadromous life history pattern (*i.e.*, a "freshwater-resident" strategy). It has been

common practice to refer to non-anadromous individuals that complete their entire life history cycle (incubating, hatching, rearing, maturing, reproducing, and dying) in freshwater as rainbow trout, while referring to those emigrating to and maturing in the ocean as steelhead. However, this terminology does not capture the complexity of the life history cycles exhibited by native *O. mykiss*. Individuals can complete their life history cycle completely in freshwater, or they can migrate to the ocean after one to three years, and spend two to four years in the marine environment before returning to freshwater rivers and streams to spawn.

Additionally, "rainbow trout" which have completed their life history cycle entirely in freshwater sometimes produce progeny which become anadromous and emigrate to the ocean and return as adults to spawn in freshwater. Conversely, it has also been shown that steelhead may produce progeny which complete their entire life cycle in freshwater. This switching of life history strategies has been demonstrated by studying the microchemistry of *O. mykiss* otoliths (small inner ear bones), where time spent in marine and fresh waters can effectively be tracked by the presence or absence of certain ocean-derived elements in the bone tissue (Zimmerman 2005). Zimmerman and Reeves (2000) used this technique to uncover occasional life history switching in *O. mykiss* populations in Oregon. O. *mykiss* in the SCCCS Recovery Planning Area have not yet been examined in this way, but various lines of evidence (*e.g.*, inland resident fish in systems such as the upper Old Creek and Arroyo Grande Creek exhibiting smolting characteristics, river systems producing smolts with no regular access for adult steelhead) indicate that switching between freshwater and anadromous life cycles is likely occurring (M. Capelli, personnel communication,). The cues that trigger this phenomenon are unknown, but may be linked to environmental variation (Satterthwaite *et al.* 2012, 2010, 2009, Hayes *et al.* 2011b, Sogard *et al.* 2011). For example, juvenile residency can be strongly influenced by the hydrologic cycle in South-Central California, where extended droughts can cause juveniles to become land-locked and therefore unable to reach the ocean (Boughton *et al*. 2009, 2006).

Lastly, there is a third type of life history strategy displayed by *O. mykiss* that is referred to as "lagoon-anadromous." Bond (2006), working at a study site in northern Santa Cruz County, has recently shown that each summer a fraction of juvenile *O. mykiss* over-summered in the estuary of their natal creek. Like South-Central California estuaries, this estuary was cut off from the ocean during the summer by the formation of a sandbar spit, creating a seasonal lagoon. Bond (2006) showed that many juveniles grow fast enough after their first year of lagoon rearing to migrate to the ocean, and most enter the ocean at a larger size than the same year class fish rearing in freshwater habitats of the stream system. Larger size generally enhances survival in the ocean, and the lagoon-reared fish represented a large majority of the returning adult spawning population (Hayes *et al.* 2008, Bond 2006). Steelhead populations in the SCCCS Recovery Planning area have not been investigated to determine whether or to what extent they may exhibit this life history strategy, though estuarine conditions in many basins are similar those which have been investigated and documented in Central Coast basins.

Closely related to these life history strategies is the use by steelhead of a wide variety of habitats over their lifespan, including river mainstems, small montane tributaries,

estuaries, and the ocean. Steelhead move between these habitats because each habitat supports only certain aspects of what the fish require to complete their life cycle. Different populations frequently differ in the details of the times and habitats that they utilize while pursuing the general pattern of the anadromous life cycle; these differences can reflect the evolutionary response of populations to environmental opportunities, subject to a variety of biological constraints that are also a product of evolution.

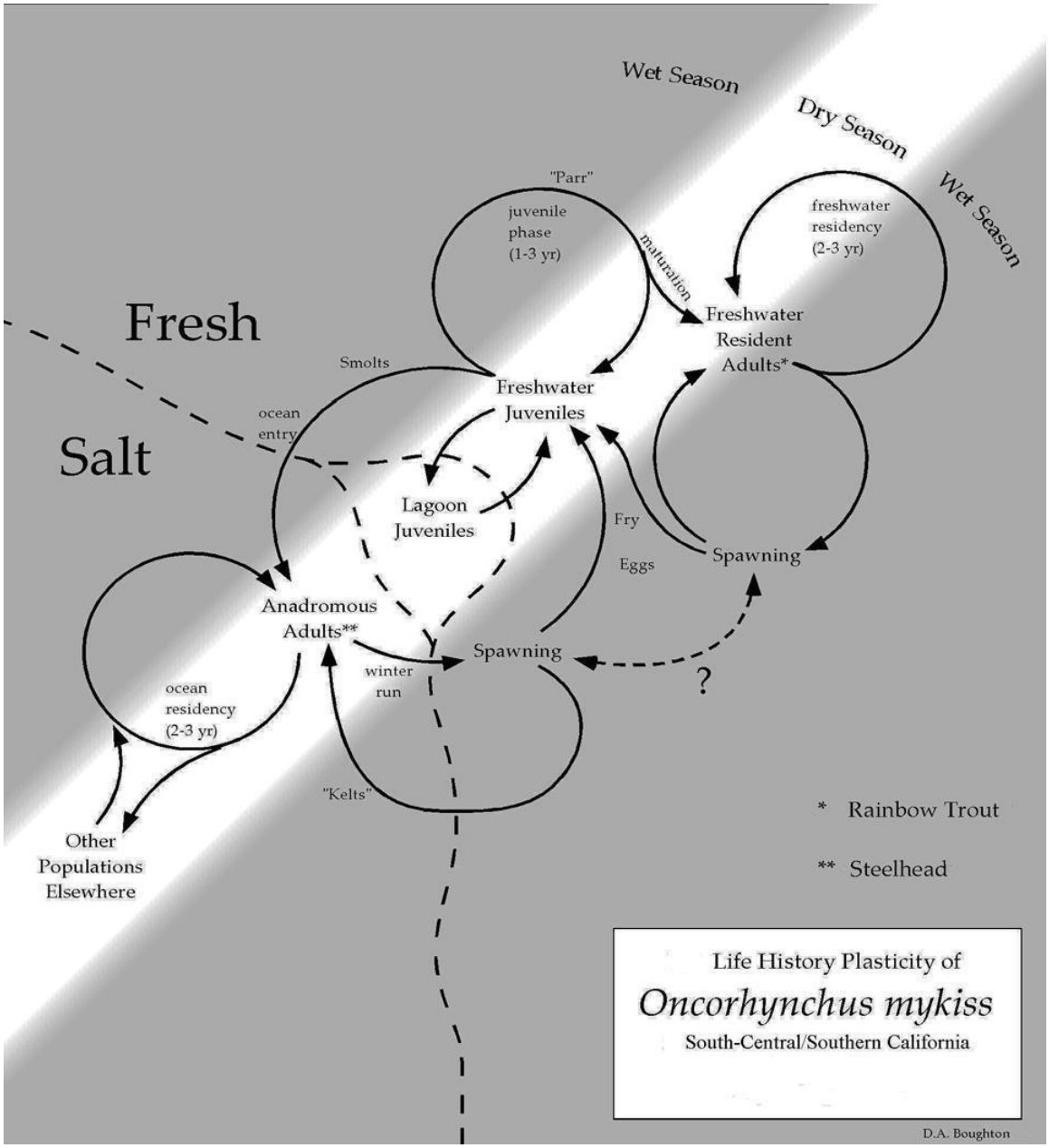


Figure 2-1. Summary of the various life history strategies exhibited by South-Central California Coast *O. mykiss* and the life stage specific terminology.

Within each of the three basic life history strategies (fluvial-anadromous, freshwater-resident, and lagoon-anadromous), there is additional variation, including examples of finer-scale habitat switching, such as multiple movements between lagoon and freshwater habitats in the course of a single summer in response to fluctuating habitat conditions; and also so-called "adfluvial" populations that inhabit freshwater reservoirs but spawn in tributary creeks (Hayes *et al.* 2011a, 2011b, 2008, M. Capelli, personnel communication).

Figure 2-2. Adult Steelhead (*O. mykiss)* (approx. 76 cm), Uvas Creek, Pajaro River, Monterey County, 2012.

Figure 2-3. Juvenile *O. mykiss* (approx. 10 cm), Trout Creek, Salinas River, Monterey County, 2008. (Courtesy Jenna Voss)

Figure 2-4. Steelhead smolts (approximately 19 cm), Arroyo Seco, Salinas River, Monterey County, 2011 (Courtesy Monterey County Water Resources Agency)

2.2 SPECIES FRESHWATER DISTRIBUTION AND POPULATION STRUCTURE

Differences between the historical and current distributions of South-Central California Coast steelhead illustrate their present threatened status. Many anadromous populations have become extirpated, particularly near the southern extent of their range (Boughton *et al.* 2006, 2005, Boughton and Fish 2003, Augerot 2005). Individual anadromous populations within this SCCCS Recovery Planning Area have been severely reduced or in some cases extirpated (Table 2-1, Figure 2-5). Some smaller watersheds may have originally supported only sporadic steelhead runs, or intermittent resident populations that experienced repeated local extinctions and recolonizations by anadromous immigrants in dry and wet cycles, respectively. This aspect of the freshwater distribution and population structure of *O. mykiss* has not been extensively studied, and as a result is not well understood (Boughton *et al*. 2006).

NMFS conducted an extensive *O. mykiss* population survey (targeted primarily at juveniles) in 2002 of most of the coastal watersheds within the South-Central California Coast Steelhead (SCCCS) Recovery Planning Area (Boughton and Fish 2003). Of the 46 watersheds in which steelhead were known to have occurred historically, between 37 and 43 percent were still occupied by either resident fish or

steelhead (a range was reported for the occupancy estimate because several watersheds could not be surveyed). Three watersheds were considered vacant of steelhead because they were dry, 17 were considered vacant due to the presence of impassible barriers to all known spawning habitat, and six were considered vacant because the survey found no evidence of *O. mykiss*. Seventeen watersheds with no known historical record of steelhead occurrence were surveyed (primarily for juveniles); none of these were found to be occupied during the 2002 survey (Table 2-1, Figure 2-5).

One of the objectives of this Recovery Plan is to maintain the current distribution of steelhead and restore distribution to a variety of previously occupied areas. Fish-passage barriers appear to have played a large role in watershed-wide extirpations of steelhead; however, in many cases, ancestors of sea-run steelhead continue to persist as resident populations above barriers in these same stream systems, and in some cases produce progeny that emigrate downstream, past the barriers to the ocean as smolts. In an investigation of the contraction of the southern range limit of *O. mykiss*, it was found that the majority (68%) of anadromous population extirpations were associated with anthropogenic barriers which restricted the use of upstream habitats for spawning and rearing by the anadromous form of *O. mykiss.* Between 58% and 65% of these stream systems maintain *O. mykiss* populations, either above or below the anthropogenic barriers (Boughton *et al.* 2005). Land use practices have also contributed significantly to the reduction in steelhead distribution, particularly in mainstem habitats such as the Pajaro and Salinas Rivers and Pismo and Arroyo Grande Creeks within the Interior Coast Range and San Luis Obispo Terrace BPGs.

These resident populations could include fish that are considered naturally persistent residents, descendants of steelhead that have been blocked from downstream emigration by barriers (including irregular or inadequate flows to the ocean) and have been forced to adopt a resident life cycle strategy (*i.e.*, "residualized" populations), or in some cases perhaps progeny of stocked *O. mykiss* found above barriers to steelhead migration (Boughton *et al.* 2005).

Table 2-1. South-Central California Coast watersheds historically occupied by populations of steelhead (listed from north to south). Several watersheds with historical populations now have barriers that block migration to portions of the watershed.[1]

BASIN	EXTANT?
Pajaro River	Yes
Salinas River	Yes
Carmel River	Yes
San Jose Creek	Yes
Malpaso Creek[2]	Yes
Garrapata Creek	Yes
Rocky Creek	Yes
Bixby Creek	Yes
Little Sur River	Yes
Partington Creek	Yes
Big Creek	Yes
Vicente Creek[2]	Yes
Mill Creek	Yes
Prewitt Creek	Yes
Plaskett Creek	Yes
Willow Creek - Monterey	Yes
Alder Creek	Yes
Villa Creek Monterey	Yes
Salmon Creek	Yes
San Carpoforo Creek	Yes
Arroyo de la Cruz	Yes
Little Pico Creek	Yes
Pico Creek	Yes
San Simeon Creek	Yes
Santa Rosa Creek	Yes
Villa Creek – SLO	Yes
Cayucos Creek	Yes
Old Creek	Negative obs.[3]
Toro Creek	Dry[4]
Morro Creek	Yes
Chorro Creek	Yes
Los Osos Creek[2]	Yes
Islay Creek	Yes
Coon Creek	Yes
Diablo Canyon	Yes
San Luis Obispo Creek	Yes
Pismo Creek	Yes
Arroyo Grande Creek	Yes

[1] A watershed includes all of the tributaries and main-stem which share a common outlet to the ocean.
[2] Data from: Becker, *et al. 2008,* Boughton *et al. (2005),* Sleeper *(2002),* Titus *et al. (2010), M. Capelli, NOAA-NMFS, personal communication (2007-2012),* M. Larson, California Department of Fish and Game, personal communication (2007-2011),.
[3] "Negative obs." means juveniles were not observed during a spot-check of best-occurring summer habitat in 2002; however, such spot observations should not be interpreted as definitive determinants of absence of O. mykiss. Toro Creek has an adfluvial population above of *O. mykiss* above Whale Rock Reservoir.

[4]"Dry" indicates the stream had no discharge in anadromous reaches during the summer of 2002; because of the high variability of the hydrologic regime, such spot-checks do not necessarily reflect the potential suitability of such reaches for migration, spawning, or rearing of *O. mykiss*.; however, such an assumption may not be warranted since rearing juvenile steelhead can make use of ephemeral reaches (Boughton *et al. 2009)*. See Boughton *et al. (2005)*. The California Department has previously report juvenile *O. mykiss* in upper Toro Creek in 1997.

Several reports describe the historical steelhead populations of the SCCCS Recovery Planning Area (Boughton *et al*. 2005, Boughton and Goslin 2006, Boughton *et al*. 2006). Using this information, the TRT proposed a structure for steelhead of the SCCCS Recovery Planning Area composed of five BPGs (Table 2-2). The division of steelhead populations into Biogeographic Population Groups (BPG) utilized two basic rules: First, populations were sorted into a coastal super-group and an inland super-group, based on whether or not the most potential freshwater habitats lay on an ocean-facing watershed subject to marine-based climate inversion and orographic (*i.e.,* lifting) precipitation from offshore weather systems. Second, within the coastal and inland super-groups, populations were sorted into groups defined by contiguous areas with broadly similar physical geography and hydrology. The combinations of these physical characteristics represent differing natural selective regimes for steelhead populations utilizing the individual watersheds. These differing physical characteristics have led to life history and genetic adaptations that can enable the populations to persist in the widely varying and distinctive habitat regimes represented by the five BPGs. The purpose of delineating the BPGs is to guide recovery efforts across the SCCCS Recovery Planning Area to ensure the preservation and recovery of the range of natural diversity of the SCCCS Recovery Planning Area. From north to south, these BPGs are known as: Interior Coast Range, Carmel River Basin, Big Sur Coast, and San Luis Obispo Terrace (Figure 2-5).

Table 2-2. Ecological characteristics of BPGs in the South-Central California Coast Steelhead Recovery Planning Area (originally Table 4 in Boughton *et al*. 2007b).

South-Central California Coast Steelhead ESU					
	Ecological Characteristics				
Population Group	**Migration Corridor**	**Migration reliabilit**[1]	**Summer Climate Refugia**[1]	**Intermittent Streams**	**Winter Precipitation**
Interior Coast Range[2]	Long alluvial valleys	Moderate/Low	Montane	Many	Mostly <75 cm (highlands) [3]
Carmel River Basin	Medium Valley	Moderate	Marine+ Montane	Some	30 – 90 cm3
Big Sur Coast	Short, steep	High	Marine	Few	75 – 135 cm
San Luis Obispo Terrace	Coastal Terrace	Moderate	Marine +Montane	Some	60 – 90 cm (highlands)

[1] Inferred reliability under an un-managed flow regime.
[2] The inclusion of the Pajaro River population in this group is debatable, since much of its best freshwater habitat currently occurs in the redwood forest at the southern end of the Santa Cruz Mountains – ecologically quite different from the chaparral watersheds of the other eat-slope populations
[3] Except in the Santa Cruz Mountains of the Pajaro system, which are wetter.

The separate watersheds comprising each BPG are generally considered as individual *O. mykiss* populations (*i.e.,* one watershed = one population of steelhead). Thus, single BPGs encompass multiple watersheds and multiple *O. mykiss* populations. However, many coastal watersheds in several of the BPGs (*e.g.*, Big Sur Coast and San Luis Obispo Terrace BPGs) are relatively small, and may be capable of supporting only small steelhead runs. The basis for the persistence of independent steelhead populations in these small watersheds is uncertain and further research is needed. (See Chapter 13, South-Central California Coast Steelhead Research, Monitoring, and Adaptive Management). The TRT (Boughton *et al.* 2007b) proposed that at least three scenarios (not necessarily mutually exclusive) are plausible:

1. Some of the populations in the coastal BPGs, though small, may be exceptionally stable and sustain the continued presence of steelhead in neighboring watersheds via adult dispersal between watersheds (an independent population supporting one or more dependent populations, thus forming a metapopulation).
2. Adult dispersal between neighboring watersheds within a coastal BPG may be common enough to knit together the steelhead in individual watersheds into a small number of "trans-watershed" populations (an independent population comprised of the fish from two or more neighboring streams, thus forming a metapopulation).
3. The populations in the smaller coastal basins (*e.g.,* in the Big Sur Coast and San Luis Obispo Terrace BPGs) may be dependent upon occasional or frequent adult dispersal pulses from populations in the larger inland basins (*e.g.,* Interior Coast Range or Carmel River Basin BPGs.)

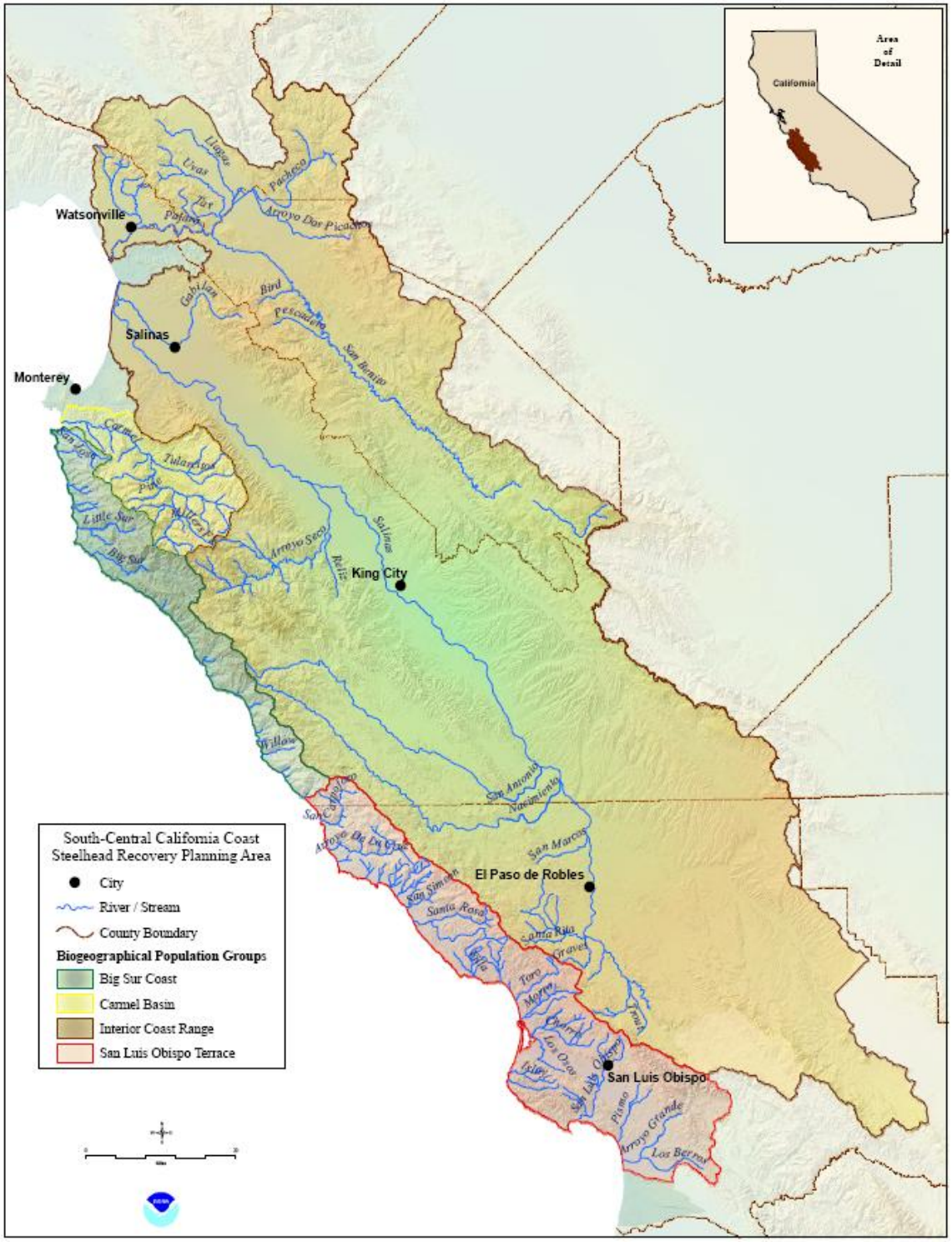


Figure 2-5. Biogeographic Population Groups (BPGs) in the South-Central California Coast Steelhead Recovery Planning Area (after Boughton *et al*., 2007b).

In characterizing the historic, pre-European settlement population structure of the SCCCS Recovery Planning Area, the TRT: 1) identified the original anadromous *O. mykiss* populations and attempted to determine which ones were still extant; 2) delineated the potential unimpaired geographic extent of each population on a watershed scale; 3) estimated the relative potential viability of each population in its (hypothetical) unimpaired state; and 4) assessed the potential demographic independence of each population in its (hypothetical) unimpaired state Boughton and Goslin 2006, Boughton *et al.* 2006, Helmbrecht and Boughton 2005). This analysis entailed a consideration of available historical and current data on the distribution and abundance of *O. mykiss*, new genetic data, landscape data, climate data, and stream discharge data. However, data limitations, particularly a lack of long-term run-size data, prevented the TRT from providing definitive characterizations of pre-European or current anadromous *O. mykiss* populations, including the geographic extent of individual populations, their intrinsic viability, or demographic independence. For a discussion of the constraints imposed by limited relevant data see Boughton and Goslin (2006) and Boughton *et al*. (2006). See Appendix B, Watershed Intrinsic Potential Rankings, Appendix C, Composition of SCCCS Recovery Planning Area Steelhead BPGs.

2.3 SPECIES ABUNDANCE

One of the recovery objectives for steelhead is to increase abundance of steelhead, including the expression of all life history forms and strategies. Current documented population abundances are extremely small; but the run size for most watersheds continues to be poorly characterized. Additionally, the presence of steelhead in watersheds is often sporadic. The status of steelhead populations along the West Coast was assessed in 1996 by the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) Biological Review Team (BRT) (Busby *et al*. 1996). In 2002 NMFS conducted an extensive survey of the geographic distribution of *O. mykiss* within south-central and southern California (Boughton and Fish 2003). Of the 36 watersheds that historically supported anadromous runs, between 86 percent and 94 percent continue to be occupied by native *O. mykiss* (a range of occupancy was reported because several basins could not be accessed). Occupancy was also determined for 18 basins with no historical record of anadromous *O. mykiss*; three of these basins (Los Osos, Vicente, and Villa creeks) were found to be currently occupied by *O. mykiss*. As a follow-up West Coast Status review Good *et al*. (2005) reported three new significant pieces information for the SCCCS DPS: 1) an updated time-series data regarding adult spawner counts at San Clemente Dam on the Carmel River; 2) NMFS' 2002 assessment of the geographic distribution of *O. mykiss* within its historic range (see above); and 3) changes in harvest regulations for *O. mykiss.*

The status of the steelhead within California was subsequently reviewed by Helmbrecht and Boughton (2005), and again in 2011 (Williams *et al*. 2011). The following summarizes the findings from these status reviews:

The steelhead populations in this region have declined dramatically from estimated annual runs totaling 27,000 adults near the turn of the century to approximately 4,740 adults in 1965 to several thousand total adults, with a large degree of inter-annual variability (Busby *et al*. 1996, Good *et al*. 2005, Williams *et al.* 2010). However, this run-size estimate is based on information from only five major watersheds bearing steelhead (Pajaro, Salinas, Carmel River, Little Sur, and Big Sur Rivers) located in the northern portion of the SCCCS Recovery Planning Area. Run-size estimates from coastal and inland watersheds south of the Big

Sur have generally not been estimated or recorded. Additionally, available run-size estimates represent only average annual estimates, and do not describe the wide annual variation in run-size that would be expected in a region with a highly variable climate and habitat conditions.

The BRT further noted that information was available to compute a trend for adult escapement for only one stock within the DPS – the Carmel River above San Clemente Dam. These Carmel River data indicate a significant decline of 22 percent per year from 1963 to 1993, with a recent average 5-year adult count of only 16 adult spawners recorded at San Clemente Dam. The BRT believed that general trends in the SCCCS DPS could be inferred from this early-1960 to early-1990 escapement data. The BRT also noted that the relationship between anadromous and non-anadromous *O. mykiss*, including possibly residualized populations upstream of impassible dams, while unclear, was likely to be important in the management of this species.

The Carmel River data are the only time-series data for the SCCCS DPS. Data collected since the 2005 BRT status review indicates that the abundance of anadromous *O. mykiss* spawners in the Carmel River has increased. Continuous data have been collected for the period from 1988 through 2012 (however these counts are incomplete because fish spawning below San Clemente Dam are not included). Counts from the start of the 1988-2002 period included three consecutive years with no fish reported (*i.e.,* in 1988, 1989, and 1990). A pen rearing program was established for juvenile *O. mykiss* using facilities at the Monterey Bay Steelhead Trapping Program and the Granite Canyon Marine Lab; fry from the artificially spawned adults were released above San Clemente Dam in the early 1990's. Steelhead counts increased from a single adult reported in 1991, to 775 adults reported in 1997, with a maximum of 881 adults reported in 2002. The BRT noted that the rapid increase in the number of returning adult anadromous *O. mykiss* spawners to the Carmel River could be attributed to a combination of factors, including improved freshwater conditions, improved resilience of populations, high stray rates, or ability of resident *O. mykiss* to produce smolts. The BRT also noted that while some component of the increase is probably due to improved ocean conditions during this period, it should not be assumed that comparable increases have occurred in other watersheds for the SCCCS DPS. However, the reported annual count (May 2009) of adult steelhead show a significant decrease: 95 fish at San Clemente Dam, and 21 fish at Los Padres Dam. These counts compare to average counts of 429 and 129 fish at San Clemente Dam and Los Padres Dam, respectively, since the end of the last drought in 1991 (Williams et al. 2011). The most recent (2011-2012) counts for the Carmel River indicate 470 adults at the San Clemente Dam, and 175 adult the Los Padres Dam, (Monterey Peninsula Water Management District 2012).

Since the listing of South-Central California steelhead, there have been increased efforts made to make periodic observations of adults as well as more systematic monitoring on a few watersheds with recently constructed fish passage facilities or active restoration efforts. For example, the Pajaro, lower Salinas River and the Carmel Rivers.

Finally, the BRT reported that the California Department of Fish and Game (CDFG) has prohibited sport harvest in the ocean (incidental ocean harvest is rare), and imposes significant angling restrictions within the anadromous waters of the SCCCS DPS (*e.g.,* restrictions on timing, location, and gear used for angling). However, CDFG continues to allow summer trout fishing in significant parts of the Salinas River system (*i.e.,* upper Arroyo Seco, Nacimiento River above barriers, upper Salinas

River, Salmon Creek, and the San Benito River in the Pajaro River system with zero bag limits. Additionally, a few other creeks have summer catch-and-release regulations. While there is indirect evidence that such fishing pressure has resulted in minimal or no mortality to *O. mykiss*, the reduction in risk to listed *O. mykiss* cannot be estimated quantitatively from the existing data because the natural abundance of *O. mykiss* is not quantitatively known.

In summary, while a majority of watersheds historically supporting *O. mykiss* are still occupied (often with individuals currently able to express only a resident life history strategy), steelhead run sizes have been sharply reduced. The three watersheds most likely exhibiting the largest annual anadromous runs (*i.e.*, Pajaro, Salinas, Carmel) have experienced declines in run size of 90 percent or more. Present population trends within individual watersheds that continue to support steelhead runs are generally unknown, and may vary widely between water-years. Available run-size estimates for all watersheds represent only average annual estimates that likely include wide annual variations expected in a region with a highly variable climate. However, these averages are extremely small, and raise the question of how such small runs of anadromous fish persist (potentially either by dispersal from some source population, and/or by consistent production of smolts by local populations of freshwater, non-anadromous *O. mykiss*. The consensus of the most current BRT was that the status of the SCCCS DPS has not changed appreciably in either direction since publication of the initial status review (Busby *et al.* 1996), and that SCCCS DPS is still in danger of extinction (Williams *et al*. 2011).

2.4 SPECIES GENETIC STRUCTURE AND DIVERSITY

A recovery objective for steelhead is to restore and conserve genetic diversity and interchange of genetic material between and within populations. Since the late 1990s, a number of genetic studies have been conducted to elucidate the structure of *O. mykiss* populations within the SCCCS Recovery Planning Area (Martìnez, *et al.* 2011, Clemento *et al.* 2009, Pearse and Garza 2009, Girman and Garza 2006, Nielsen 1999, 1994, Nielsen *et al.* 2001, 1997, 1994c). These studies have provided useful insights into the historic distribution of the species, as well as the potential influence of past (and current) stocking practices within the watersheds historically occupied by native *O. mykiss*. Berg and Gall (1988) surveyed steelhead populations throughout California. They discovered considerable variability among California populations, but did not discern a clear geographic pattern to the variation. Busby *et al.* (1996) also reported a high level of genetic variability in California coastal populations, including four from the SCCCS Recovery Planning Area. Busby *et al.* (1996) also reported an allozyme allele fixed in some populations but entirely absent in others, which is unprecedented in anadromous salmonids, except when comparing populations at the extreme ends of their ranges.

Sundermeyer (1999) examined five microsatellite loci from fourteen populations of *O. mykiss* in the Pajaro River. Most of these populations were found to be closely related to two populations from the San Lorenzo River which is immediately north but outside of the SCCCS Recovery Planning Area, and the source of hatchery-reared *O. mykiss* planted in the Pajaro River system. Native non-anadromous *O. mykiss* above barriers to upstream migration were less closely related to the San Lorenzo populations that those *O. mykiss* located below barriers. The *O. mykiss* from four locations above barriers to upstream migration (Llagas, upper Uvas, Bodfish, and Dos Picachos Creeks) were the mostly distantly related from the San Lorenzo River fish, and from each other.

Recent genetic investigations have shed light on the relationship between steelhead and the *O. mykiss* above barriers within the SCCCS Recovery Planning Area. Girman and Garza (2006) and Clemento *et al.* (2009) reported that above-barrier *O. mykiss* were more closely associated with below-barrier populations than to populations from other watersheds; that they were more related to the fish below the barrier than to any other geographically proximate populations. In addition, their results supported the idea that planted hatchery fish from other watersheds have had no detectable influence on the genetics of above-barrier populations. These results indicate that the above-barrier populations are not the descendants of hatchery fish. They are most likely the descendants of contiguous *O. mykiss* populations, because most of these areas have historical accounts of steelhead populations prior to construction of the barriers (Becker *et al.* 2008, Swift *et al.* 1993, Benke 2002, 1992, Hubbs 1946, Jordan and Gilbert 1881). While the fish that remain above barriers do not have an opportunity to interbreed with adult steelhead, they can, and in some cases do, produce progeny that emigrate downstream past the barriers to the ocean as smolts.

2.5 HABITAT CHARACTERISTICS OF THE SOUTH-CENTRAL CALIFORNIA COAST STEELHEAD RECOVERY PLANNING AREA

The major steelhead bearing watersheds in the SCCCS Recovery Planning Area include the Pajaro, Salinas, Carmel, Little and Big Sur Rivers (Good *et al*. 2005, Busby *et al*. 1996,). South of the Big Sur Coast, several major drainages and a number of smaller streams also supported runs of anadromous *O. mykiss* (of unknown size and frequency); these include the San Carpoforo, Arroyo de la Cruz, Pico and Little Pico, San Simeon, Santa Rosa, San Luis Obispo, Pismo, and Arroyo Grande Creeks (Titus *et al*. 2010, Becker *et al.* 2008, Swift *et al.* 1993).

Significant portions of the upper watersheds within the SCCCS Recovery Planning Area are contained within Los Padres National Forests. These forests are managed primarily for water production and recreation, with limited grazing and oil, gas, and mineral production (United States Forest Service, 2005a, 2005b, 2004, Berg *et al*. 2004, Stephenson and Calcarone 1999). Additionally, a significant amount of land within the SCCCS Recovery Planning Area is protected within military installations, and in the southern portions, within large scale regional parks. Urban development is centered in coastal areas and inland valleys, with the most expansive and densest urban development located within the Pajaro, Carmel, and Salinas River valleys. (Kier Associates and National Marine Fisheries Service 2008a, 2008b, Hunt & Associates 2008a, Keeley 1993, Hornbeck 1983; Lantis *et al*. 1981, Lockmann 1981).

The SCCCS Recovery Planning Area is comprised of geologically young mountainous topography with a number of inland valleys and coastal terraces. The geomorphology (*i.e.,* the shape and composition of the land surface) is strongly influenced by tectonic activity and various other signs of stress (*e.g.*, highly folded and faulted rocks of varying types), including metamorphic formations (*i.e.,* rocks that have changed under pressure and heat over time). The Coast Ranges (consisting of the Diablo, Temblor, and Santa Lucia Mountains) are made up of sedimentary formations (*i.e.*, sediment deposited out of the air, ice, and/or water flows), granitic formations (*i.e.,* formed from cooled magma), and the widespread Franciscan formation (comprised of sandstones derived from erosion of volcanic highlands into deep marine basins). The legacy of tectonic activity and other physical stresses has created the steep slopes and unconsolidated rock formations that characterize this region. These geologic factors combined with an active, annual fire-cycle and intense winter storms have created spatially complex and frequently unstable river and

stream habitats to which anadromous fishes and other aquatic species have adapted through evolutionary processes (Boughton *et al*. 2006, Sugihara *et al.* 2006, Norris and Webb 1990, Faber *et al*. 1989, Endler 1986, 1977, Felton 1965, Mayr 1963).

The SCCCS Recovery Planning Area is characterized by ten broad native terrestrial plant communities within the Californian floristic province: Estuarine Wetlands, Beach and Dunes, Riparian Forests, Coastal Prairie, Coastal Sage Scrub, Oak Woodlands, Chaparral, Valley Grasslands, Vernal Pools, and South Central California Conifer Forests (Barbour, *et al*. 2007, Holland 1996, Ferren *et al*. 1995, Sawyer and Keeler-Wolf 1995, Hickman 1993). Upland areas of the northern portion of the SCCCS Recovery Planning Area are dominated by a mix of Chaparral, Valley Grasslands, Oak Woodlands, and South-Central California Conifer Forests. Upland areas of the southern portion of the SCCCS Recovery Planning Area are dominated by South-Central Coastal Scrub, Valley Grassland, Oak Woodland, and South Central California Conifer Forests. Both of these upland areas are subject to catastrophic wildfires (Sugihara *et al.* 2006, Keeley 2006). Riparian forests consist of deciduous species. Large segments of the valley grasslands and riparian forests have been converted for agricultural, residential, and a variety of other commercial land-uses (Berg *et al*. 2004, California Department of Fish and Game 2003, Stephenson and Calcarone 1999, Holland 1996, Kreissman 1991, Mayer and Laundenslayer 1988, Warner and Hendrix 1984, Capelli and Stanley 1984). However, the interior uplands within the four U.S. National Forests are largely undeveloped, and a number of large parks, preserves, and greenbelts have been created in recent years on non-Federal lands.

The climate in the California floristic province is Mediterranean, with long dry summers and short, sometimes intense cyclonic winter storms. Rainfall is restricted almost exclusively to the late fall, winter months and early spring months (November through May. The California floristic province is subject to an El Niño/La Niña weather cycle which can significantly affect winter precipitation, causing highly variable rainfall between years. Additionally, there is a wide disparity between winter rainfall from north to south, as well as between coastal plains and inland mountainous areas. Mean annual precipitation ranges along the coast (north to south) from 32 to 24 centimeters (cm) per year, with larger variations (24-90 cm/year) from the coast inland (west to east) due to the orographic effects of the various mountain ranges. Fog along the coastal areas is typical in late spring and summer, extending inland along coastal reaches with valleys extending into the interior. This fog has been shown to moderate conditions for rearing *O. mykiss* in these lower, coastal reaches. South-Central California also experiences seasonally high, down slope winds during the early fall and winter that blow through the mountain. These winds, which can reach 40 miles per hour, are warm and dry and can severely exacerbate brush or forest fires, especially under drought conditions (Mastrandrea *et al*. 2009, Miller and Schlegel 2006, Haston and Michaelsen 1997, Philander 1990, Leipper 1994, Ryan and Burch 1992, Hornbeck 1983, Karl 1979, Felton 1965).

River flows vary greatly between seasons, and can be highly "flashy" (rapidly increased flows with high volume but short duration) during the winter season, changing by several orders of magnitude over a few hours in response to winter storms. Snow accumulation is generally small and of short duration, and does not contribute to peak run-off in most years. Baseflows in some river reaches can be influenced significantly by groundwater stored and transported through faults and fractured rock formations. Many rivers and streams naturally exhibit interrupted baseflow patterns (alternating channel reaches with and without perennial surface flow) controlled by geologic

formations, and a strongly seasonal precipitation pattern characteristic of a Mediterranean climate. Water temperatures are generally highest during summer months, but can be locally controlled by springs, seeps, and rising groundwater, creating micro-aquatic conditions suitable for salmonids (Boughton, *et al*. 2007a, Faber *et al.* 1989, Mount 1995, Jacobs 1993, Reid and Wood 1976).

Within the SCCCS Recovery Planning Area steelhead habitat occurs in chaparral ecosystems which differ in significant ways from steelhead habitats found in snow-fed and/or conifer-lined ecosystems in the Sierra Nevada or North and Central Coasts of California. From the perspective of steelhead ecology, it is useful to divide these chaparral ecosystems which dominate the SCCCS Recovery Planning Area into two categories: coastal basins draining directly westward into the ocean, and inland basins set back from the coast, often separated from it by extensive mountain ranges. The inland basins are relatively few, large, and have a terrestrial climate whereas the coastal basins tend to be small, numerous and a heavily marine-influenced climate. These differences (and others that result from them, such as the reliability of suitable summer temperatures) likely impose different sorts of limiting factors on steelhead populations. Coastal basins are often characterized by a "mountain-terrace" system, in which a broad coastal terrace is backed by a steeper mountain range. These types of systems occur along the southern coast of Santa Luis Obispo County. The mountains harvest orographic rain from incoming storm systems, creating flashy streamflows that carve out well-shaded step-pool systems in the uplands, and braided gravel-bed streams and pool-riffle systems in the terraces. They also produce seasonal lagoons at the interface of the stream with the ocean. Each of these parts of the stream system produces habitat for a particular life stage of steelhead. Due to the movement of water, sediment and fish, stream systems function as integrated wholes with steelhead acting as effective strategists using the entire suite of resources provided them by the coastal and inland basins of the SCCCS Recovery Planning Area.

2.6 SOUTH-CENTRAL CALIFORNIA COAST STEELHEAD FRESHWATER LIFE CYCLE HABITAT USE

Steelhead spend a majority of their life in the ocean, but must enter freshwater to reproduce. Understanding the interaction between steelhead and their freshwater habitats is critical for effective steelhead recovery and management. Many of the naturally limiting factors described in this section that affect the growth and survival of juvenile steelhead in their freshwater phase are exacerbated by the artificial modification freshwater habitats and watershed processes that create and sustain these habitats. The freshwater habitats used by steelhead within the SCCCS Recovery Planning Area occur in two types of watersheds featuring distinctly different environmental regimes. One type is the series of rivers that flow through hot inland valleys and cut through coastal ranges to the sea. These watersheds have warm seasonal climates and are in coastal rain shadows. The other freshwater habitats are the small, steep coastal watersheds with higher rainfall, lower air temperatures, and a greater proportion of perennial streams (Boughton *et al*. 2006, Boughton *et al.* 2007b).

The *O. mykiss* life cycle can be conceptualized as a biological network in which environmental opportunities can be represented as a set of linkages:

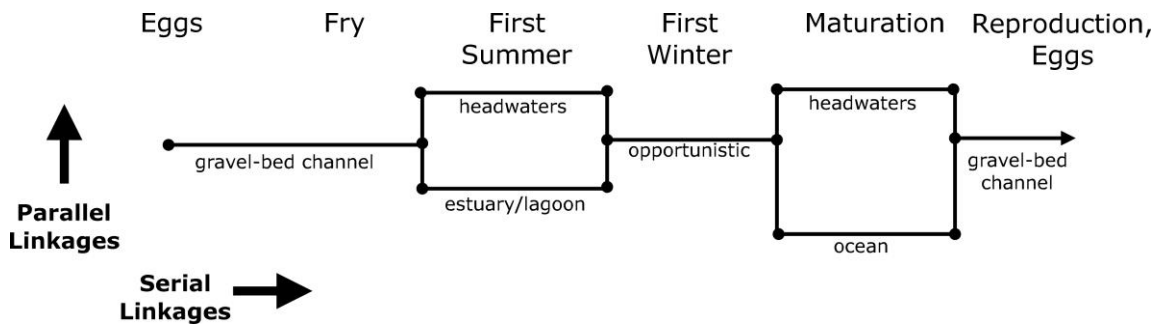


Figure 2-6. South-Central California Coast *O. mykiss* Life Cycle Habitat Linkages (Schwing *et al.* 2010, after Boughton).

The sequence of habitats required for the fish to complete the egg-to-egg life cycle involves a series of linkages, the loss of any of which prevents the completion of the life cycle. While serial linkages are a source of vulnerability, some of the linkages can be realized through alternative pathways: for example, over-summering in different sorts of thermal refugia, such as tributary headwaters or seasonal lagoons/estuaries next to the ocean; or maturation in freshwater versus the ocean. These alternative pathways in the network increase the resilience of the population to extirpation, because if one pathway fails in a particular year, some members of the population can still complete their life cycle by pursuing an alternative pathway.

The following provides a more detailed discussion of the freshwater life cycle phases of steelhead and the environmental factors that control the successful transition between freshwater life cycle phases prior to entering the ocean life cycle phase (Schwing, *et al.* 2010, after Boughton, *et al*. 2006).

Spawning Migration. Steelhead passage limitations arising from periodic drought (or longer term climate change) is one of the principal limiting factors affecting adult steelhead (Boughton *et al.* 2006). Steelhead are iteroparous (*i.e.*, can reproduce more than once), and, to realize the evolutionary benefits of repeat spawning, must have an opportunity to both enter and exit the stream system. The migration of steelhead into freshwater spawning and rearing streams is strongly associated with higher winter and spring flows which provide a continuous hydrological connection between the ocean and upstream spawning and rearing habitats. Some large steelhead adults in this domain may remain in freshwater after spawning, and can become trapped in deep residual pools in the summer (M. Capelli, personal communication). This sort of trapping is probably a function of the precise timing, duration, and magnitude of storms in a given winter. Periodic droughts further constrain migration opportunities during dry periods, and may have a bigger effect on repeat-spawning, which requires both an in- and out-migration opportunity in a given year, followed by an in-migration opportunity a year or two later. Finally, spawning efforts may be abrogated by one or more successive high flow events following spawning that erodes the spawning redds and exposes or flushes recently laid eggs out of the redd, exposing them to predation, or terminating the incubation process prematurely.

Initial Spring Feeding. The development and hatching of *O. mykiss* eggs is controlled by temperature and dissolved oxygen, which is itself influenced by flow rates, ambient air temperature, riparian cover, and groundwater input. Following the hatching and emergence from spawning gravels juvenile *O. mykiss* (fry) either stay near the redds from which they were

hatched and establish territories, or disperse to favorable feeding areas (Boughton *et al.* 2009, Quinn 2005). Rainfall and runoff conditions conducive to adult upstream migration and spawning are also conducive to initial rearing conditions for the first spring growth of juvenile steelhead. As flows drop later in the spring and summer, rearing fish may move out of initial rearing reaches, or may continue to reside in deeper pools, where they may be trapped between temporary dry reaches of stream channel until the following winter rains reconnect perennial reaches.

An increase in rearing temperatures, either as a result of inter-annual, seasonal variability or longer-term climatic changes will likely produce warmer conditions during early rearing. If temperatures stay below about 17^0 Celsius, a warming or an increase in week-scale variability of temperature can increase the growth rate of salmonids if food is abundant. But it would also increase metabolic demand and thus reduce growth if food is limiting (Boughton *et al*. 2007b, Smith and Li 1983, Brett 1971). Consequently, the effect of warmer conditions on growth is crucially dependent on per-capita food availability, which in turn depends on a host of other factors, such as primary productivity of the stream network, biomass of terrestrial insects caught in stream drift, and stream geomorphology as it affects the territorial dynamics of juvenile *O. mykiss*.

First Rearing Summer. The hot, rain-free summers of South-Central California require that juvenile *O. mykiss* retreat for the summer to sections of the stream network that do not dry up or overheat too much. Regionally, there are two alternative mechanisms for maintaining thermal refugia: the temperature lapse rate (*i.e.*, the decrease in temperature with an increase in altitude), which maintains cool, montane uplands, and the ocean heat sink, which maintains cool conditions proximate to the coast. In many small coastal basins, these two mechanisms merge geographically, whereas in inland basins the operation of these mechanisms may be separated by a long stretch of dry or warm channel that enforces a summer-long barrier to movement. Numerous tributaries draining various mountain ranges provide a high level of redundancy in the montane thermal refugia.

Probably as important as air temperature in maintaining cool water is protection from sunshine, which in summer is often the single biggest source of heat flux into a stream (Hannah *et al.* 2008, Evans *et al*. 1998). Wind effects can also be significant (Bogan *et al*. 2003). In coastal areas, fog and onshore winds provide shade and cooling wind, respectively. In the montane refugia, the closed tree canopy appears necessary to maintain suitably cool conditions (Leipper 1994, D. Boughton, unpublished data). Therefore, the resilience of montane thermal refugia to current inter-annual seasonal or longer-term climatic changes is probably highly dependent on the resilience of the closed tree canopy.

Mountain refuges appear more vulnerable than the coastal refuges to thermal increase (Snyder *et al*. 2002), perhaps because the latter are buffered by the ocean. An alteration of fire regime, flood regime, and/or sediment may eliminate the closed riparian canopy by burning trees, increasing the depth to the water table, or destroying trees via debris flows or floods (Bendix and Cowell 2010b, May and Gresswell 2004, Bendix and Hupp 2000). The water table can be lowered not just by increased sediment deposition, but also by decreased summer base flows, driven by lowered rainfall or greater evaporative demand of plants (Tague *et al*. 2009).

Lowered summer water tables may not just indirectly affect rearing juveniles via alteration of riparian trees; it may also affect the fish directly by reducing the summertime surface

flow, and eliminating it entirely in dry parts of the rain shadow or in reaches with deep alluvium (*i.e.* response stream reaches). The gravel-bedded reaches used for spawning tend to have deep alluvium, and therefore can be especially vulnerable to loss of surface flow or incomplete riparian shading (Boughton *et al*. 2009). Timing is important for young-of-the-year development in gravel-bedded channels followed by retreat into "hydro-thermal" refugia once growth and size permits; large amounts of juvenile movement and stranding are commonly observed in South-Central California (see for example, Shapovalov 1944).

Groundwater inputs and heat-exchange with the channel-bed can serve to buffer daily and annual temperature fluctuations in a stream (Hannah *et al*. 2004, Tague *et al*. 2008). In a stable climate the ground stores heat seasonally (absorbing heat in summer and supplying heat in winter), but should have an annual net flux close to zero (Bogan *et al*. 2004). Decreased base flows during the summer may actually help the ground (channel-bed) buffer stream temperatures more effectively, by increasing the surface area of the bed-water interface, relative to the volume of water in the stream and the air-water surface area. The magnitude of such a buffering is not known, and would also probably shrink the amount of fish habitat and feeding opportunities for rearing juvenile fish.

The coastal thermal refugia are closely tied to the heat dynamics of the ocean and maritime air, and thus to the future pattern of seasonal upwelling and winds along the coast. Many tributaries and the lower sections of mainstems fall within the climatic influence of the marine inversion layer that develops in summertime. Except for the mainstems, many of these coastal streams also benefit thermally from the temperature lapse rate in the coastal mountains, as well as receiving large doses of orographic precipitation in the wintertime - the converse of the rain shadow-starved streams in more inland areas. This band of steelhead-hospitable coastal terrain is probably significantly more resilient to climate change than inland areas, and highly productive per unit of habitat. However, it is a very narrow band and so its total productivity may be limited.

Each stream system terminates at the coast with some type of estuary-lagoon system. In South-Central California, seasonal lagoons currently tend to form each summer when decreased streamflows allow marine processes to build a sand berm at the mouth of each system. Juvenile steelhead over-summer in these lagoons, where they often grow so rapidly that they can undergo smoltification at age 1 and enter the ocean large enough to experience enhanced survival to adulthood (Hayes *et al*. 2008, Bond 2006). Both effects should increase the resilience of the steelhead component of *O. mykiss*. In contrast, juveniles over-summering in some montane thermal refugia display very little or no growth during the summer (Sogard *et al*. 2009, Hayes *et al.* 2008, Boughton *et al*. 2007a, Bond 2006) .

Fall and Winter Feeding. Steelhead rearing ecology during the fall and winter is less documented, but likely is under fewer constraints than early life history or over-summering phases. Baseflows rebound in many creeks as the weather cools in September and October, and sections of channel that were dry during the summer months begin flowing again, even before the first rains of the fall. This is due to reduced evaporative demand by riparian plants. (Initial rainstorms of fall have relatively little effect on stream flows, as most precipitation gets absorbed into the ground). The cooling of the weather and the rebounding of baseflows releases over-summering fish that were trapped in small residual pools and thermal refugia, so that a relatively small number of fish potentially gain access to a large extent of stream habitat (Boughton *et al*. 2009).

In some areas of South-Central California, this time of the year is marked by peak emergence of aquatic arthropods and inputs into streams of terrestrial arthropods, suggesting the opening of increased feeding opportunities to the fish that survived the summer. Arthropod productivity appears sensitive to local geologic and vegetative factors (Rundio 2009), but where it occurs it may allow juvenile steelhead to transform relatively warm temperatures into opportunities for rapid growth (Rundio and Lindley 2008). If these opportunities occur in sparsely populated intermittent creeks, the conditions are conducive to potential rapid growth into large smolts.

The timing of these peaks of productivity and growth opportunities is likely to be modified by current inter-annual as well as longer climatic changes. Because warmer autumns would increase metabolic costs as well as well as scope for growth (Boughton *et al*. 2007a), the impact on *O. mykiss* growth and survival could be either negative or positive, depending on a sensitive balance of factors. Compared to fall feeding, winter-feeding and growth is presumably more constrained by cooler temperatures, less arthropod production, and disturbances associated with high-flow events.

Smolting and Outmigration. Intensive studies of steelhead populations in the redwood systems of Santa Cruz County indicate that most *O. mykiss* become smolts and migrate to the ocean at age 2 or 3, but a small proportion smolt at age 1 (Hayes *et al*. 2011, Sogard *et al*. 2009, Hayes *et al*. 2008, Shapovalov and Taft 1954). Since larger size at ocean entry greatly increases ocean survival (Hayes *et al*. 2008, Bond 2006, Ward *et al*. 1989), smolting at age 1 is probably only a viable strategy for fish that have achieved unusually rapid growth during their first year (Satterthwaite *et al*. 2009). Bond (2006) has shown that fish over-summering in lagoons can achieve such growth. It is possible that rapid growth can be achieved in other habitats as well (see for example, Casagrande 2012, 2010, Moore 1980), but most studies have shown growth to be slower in upland tributaries.

Quantitative data on growth and life history are not yet available for the chaparral and coastal terrace systems of the SCCCS Recovery Planning Area. It is likely that age at smolting of individual fish is based on locally adapted "decision rules", including also a "decision" as to whether to smolt at all versus maturing in freshwater. Local adaptation is likely to be dominated by a tradeoff between ocean mortality and the much greater fecundity that fish can realize by growing to a larger size in the ocean (Satterthwaite *et al*. 2009). Since ocean survival appears so strongly sensitive to size at ocean entry, the balance of anadromous versus freshwater-resident fish may be sensitive to juvenile growth rates. As noted above, warmer temperatures offer the possibility of either reducing or accelerating juvenile growth, depending on food availability, which itself may respond inter-annual and longer climatic effects on precipitation, riparian vegetation, and life cycle patterns sensitive to temperature, and nonlinear food-web dynamics.

An increase in the frequency, intensity, or duration of multi-year droughts would further limit migration opportunities for smolts. Loss of surface flow appears to occur more commonly in the deep alluvium of downstream reaches rather than in headwater tributaries (Boughton *et al*. 2009). Additionally, the sandbar barriers at the mouths of estuaries sometimes fail to breach in dry years, so drought would probably have greater impacts on migrating smolts (and migrating adults) than on the *O. mykiss* maturing in headwater tributaries (Jacobs *et al*. 2011). The loss of opportunity would force a higher proportion of fish to adopt a freshwater-maturation strategy rather than the anadromous strategy. Since freshwater residents are significantly less fecund than steelhead, the resulting population would be less resilient to

extirpation, and gene flow among populations by straying steelhead would also be reduced. All these outcomes would tend to reduce the capacity of *O. mykiss* populations to recover from and adapt to changing conditions.

Subsequent Years in Freshwater; Maturation in Freshwater. The majority of juvenile *O. mykiss* that do not smolt their first year must again cycle through stages of spring-feeding, over-summering, and fall and winter feeding, although at a larger body size. Most of these fish probably smolt at age 2 or 3 or adopt the freshwater-resident strategy, maturing and eventually spawning in a suitable section of the stream network; the proportions adopting these pathways (*i.e.,* either multiple pre-smolts rearing years or freshwater maturation and reproduction) are unknown and probably sensitive to both growth and survival at all stages of life history (Satterthwaite *et al*. 2009).

The over-summering stage probably poses the greatest constraints. Compared to young-of-the-year, older fish appear to require deeper water for over-summering (Spina 2007, Spina *et al.* 2005, Spina 2003, Spina and Johnson 1999), and thus may be more restricted to the parts of the watershed that provide well-shaded perennial pools of sufficient depth. These appear to be concentrated in headwater streams well-fed by orographic precipitation, where baseflows are stable, riparian canopies are relatively complete, and geomorphic processes produce an abundance of pools (Boughton *et al*. 2009, Harrison and Keller 2006). The pool-forming mechanisms in these uplands are highly variable, involving self-formation of step-pools, scour around large boulders that roll off hillsides, and rock outcrop which create force-pools.

The upland habitats used by older juvenile fish are a subset of the upland habitats used by the fish initially in their first summer. Consequently, vulnerabilities to repeated inter-annual seasonal changes (and longer-term climate changes) are similar to those described previously (*e.g*., loss of baseflow, loss of riparian cover). Additional factors influencing productivity of upland habitats relied upon by rearing fish for multiple years are: (1) a lower level of redundancy, due to the more restricted distribution of high-quality pool habitat; (2) the vulnerability of pools to being transiently filled by fine sediments following wildfires; and (3) the long-term robustness of step-pools and bedrock force-pools, which should tend to re-scour after being filled, and are presumably resilient to a broader range of conditions compared to the reaches further downstream (Chin *et al*. 2009, Montgomery and Buffington 1997).

In summary, while freshwater habitats provide important spawning and rearing opportunities to steelhead, the inherent instability of these habitats can limit productivity depending on the pre-smolting growth patterns of individual fish, the pattern of rainfall, run-off, and input of sediments from natural hill-slope and channel erosion processes (accelerated, including its unique fish and wildlife resources by periodic wildfires).

3. Factors Contributing to Decline and Federal Listing

"Steelhead on the west coast of the United States have experienced dramatic declines in abundance during the past several decades as a result of human-induced and natural factors. The scientific literature is replete with information documenting the decline of steelhead populations and anadromous salmonid habitats. There is no single factor solely responsible for this decline."

Factors for Decline: A Supplement to the Notice of Determination for West Coast Steelhead under the Endangered Species Act, 1996

3.0 INTRODUCTION

When evaluating a species for protection under the ESA, the law provides that the Secretary of Commerce must consider whether any one (or more) of five listing factors affect the species. Listing factors deal with those aspects of the species' biology or habitat that affect the level of threat to the species' continued persistence. The ESA requires that in developing recovery plans for listed species, each of the factors which contributed to the species' listing as threatened or endangered be addressed in the recovery actions identified in recovery plans.

The five listing factors are:

1. Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range
2. Over-Utilization for Commercial, Recreational, Scientific, or Educational Purposes
3. Disease and Predation
4. Inadequacy of Existing Regulatory Mechanisms
5. Other Natural or Human-Made Factors Affecting Continued Existence

NMFS' listing determinations regarding the SCCCS DPS (71 FR 834, January 5, 2006, 68 FR 15100, March 28, 2003, 62 FR 43937, August 18, 1997, 55 FR 24296, June 15, 1990), and supporting technical reports (*e.g.*, Boughton *et al.* 2005, Good *et al.* 2005, Busby *et al.* 1996, National Marine Fisheries Service 1996a) have provided a detailed discussion of the factors affecting steelhead at the time of listing. There was no single factor responsible for the decline of South-Central California Coast steelhead; however, of those factors identified, the destruction and modification of habitat and natural and man-made factors had been recognized as the primary causes for the decline of the SCCCS DPS.

This chapter summarizes the factors identified at the time of the listing of the species. All of these factors are still prevalent and widespread. As a result, there have been few changes to the factors affecting the species since the time of original listing. The following chapter, Chapter

4, discusses the current threats facing the SCCCS DPS and represents our current understanding of how the listing factors continue to affect the species.

3.1 FACTOR 1: Present or Threatened Destruction, Modification or Curtailment of Habitat or Range

South-Central California Coast steelhead declined in large part as a result of a wide variety of human activities, including, but not limited to, agriculture, mining, and urbanization activities that have resulted in the loss, degradation, simplification, and fragmentation of habitat. Water storage, withdrawal, conveyance, and diversions for agriculture, flood control, domestic, and hydropower purposes have greatly reduced or eliminated historically accessible habitat. Modification of natural flow regimes by dams and other water control structures have resulted in increased water temperatures, changes in fish community structures, depleted flow necessary for migration, spawning, rearing, flushing of sediments from spawning gravels, and reduced gravel recruitment. The substantial increase of impermeable surfaces as a result of urbanization (including roads) has also altered the natural flow regimes of rivers and streams, particularly in the lower reaches.

Nacimiento Dam, Nacimiento River

In addition to these indirect effects these structures have also resulted in increased direct mortality of adult and juvenile steelhead. Land-use activities associated with urban development, mining, agriculture, ranching, and recreation have significantly altered steelhead habitat quantity and quality. Associated impacts of these activities include: alteration of stream bank and channel morphology; alteration of ambient stream water temperatures; degradation of water quality; elimination of spawning and rearing habitats; fragmentation of available habitats; elimination of downstream recruitment of spawning gravels and large woody debris; removal of riparian vegetation resulting in increased stream bank erosion; and increased sedimentation input into spawning and rearing areas resulting in the loss of channel complexity, pool habitat, suitable gravel substrate, and large woody debris.

Flood Control Work –Carmel River Estuary

In addition, a significant percentage of estuarine habitats have been lost, with an average of 66 percent of estuarine habitat remaining across the SCCCS Recovery Planning Area. The condition of these remaining wetland habitats is largely degraded, with many wetland areas at continued risk of loss or further degradation. Although many historically harmful practices have been halted, much of the historical damage remains to be addressed, and the necessary restoration activities will likely require decades. Many of these threats are associated with most

of the larger river systems such as the Pajaro and Salinas Rivers, and many also apply to the smaller coastal systems such as San Jose, San Simeon, Santa Rosa, San Luis Obispo, Pismo, and Arroyo Grande Creeks (National Marine Fisheries Service 1996a).

Wetland Fill – Pismo Creek Estuary

3.2 FACTOR 2: Over-Utilization for Commercial, Recreational, Scientific, or Educational Purposes

Steelhead populations traditionally supported an important recreational fishery throughout their range. Recreational angling for both winter adult steelhead and summer rearing juveniles was a popular sport in many coastal rivers and streams until the mid-1950s. Recreational angling in coastal rivers and streams for native steelhead increased 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.

Angling for both adults and juveniles in those portions of coastal rivers and streams accessible to anadromous runs from the ocean is permitted under the CDFG's angling regulations, though the CDFG imposes significant angling restrictions within the anadromous waters of the SCCCS DPS (*e.g.*, restrictions on timing, location, and gear used for angling); however, no Fishery Management and Evaluation Plan has been approved by NMFS. The CDFG continues to allow summer trout fishing in significant parts of the Salinas River system (*i.e.*, upper Arroyo Seco, Nacimiento River above impassable barriers), Salmon Creek, and the San Benito River in the Pajaro River system with zero bag limits. Additionally, a few other creeks have summer catch-and-release regulations (California Department of Fish and Game 2011a).

Steelhead are not targeted in commercial fisheries. 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. Commercial fisheries are not believed to be principally responsible for the large declines in abundance observed along most of the Pacific coast over the past several decades.

While there is indirect evidence that such fishing pressure has resulted in minimal or no mortality to *O. mykiss*, the reduction in risk to listed *O. mykiss* cannot be estimated quantitatively from the existing data because the natural abundance of *O. mykiss* is not quantitatively known. However, poaching or harassment remains potential forms of unauthorized take of South-Central California Coast steelhead.

NMFS had previously concluded that recreational harvest is a limiting factor for South-Central California Coast steelhead (Good *et al.* 2005, Busby *et al.* 1996, National Marine Fisheries Service 1996a).

3.3 FACTOR 3: Disease and Predation

Infectious disease is one of many factors that can influence adult and juvenile steelhead survival. Specific diseases such as bacterial kidney disease, Ceratomyxosis, Columnaris, Furunculosis, 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 and salmon (Noga 2000, Wood 1979, Rucker *et al*. 1953). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases for steelhead. Warm water temperatures, in some cases can contribute to the spread of infectious diseases (Belchik *et al.* 2004, Stocking and Bartholomew 2004). However, studies have shown that native fish in unimpaired native habitat tend to be less susceptible to pathogens than hatchery cultured and reared fish (Buchanan *et al*. 1983).

Introductions of non-native aquatic species (including fishes and amphibians) and habitat modifications (*e.g.*, reservoirs, altered flow regimes, *etc*.) have resulted in increased predator populations in numerous river systems, thereby increasing the level of predation experienced by native salmonids (National Marine Fisheries Service 1996a). Non-native species, particularly fishes and amphibians such as large and smallmouth basses and bullfrogs have been introduced and spread widely. These species can prey upon rearing juvenile steelhead (and their conspecific resident forms), compete for living space, cover, and food, and act as vectors for non-native diseases (Marks *et al.* 2010, Scott and Gill 2008, Fritts and Pearsons 2006, Bonar *et al.* 2005, Dill and Cordone 1997).

***O. mykiss* – San Carpoforo Creek**

Artificially induced summer low-flow conditions may also benefit non-native species, exacerbate spread of diseases, and permit increased avian predation. NMFS concluded that the information available on these impacts to steelhead did not suggest that the SCCCS DPS was in danger of extinction, or likely to become so in the foreseeable future, because of disease or predation. It is recognized, however, that small populations such as South-Central California Coast steelhead can be more vulnerable to extinction through the synergistic effects of other threats, and the role of disease or predation may be heightened under conditions of periodic low flows or high temperatures characteristic of steelhead habitats within the SCCCS Recovery Planning Area.

Finally, the introduction of a variety of non-native plant and animal species can alter ecosystems and related food-webs in complicated and subtle ways that can have unpredictable, long term impacts on native organisms (Cucherousset and Olden 2011, Davis 2009, Lockwood *et al*. 2007, Bonar 2005, Sax *et al.* 2005, Bossard 2008, Gamradt *et al.* 1997, Gamradt and Kats 1996, Williamson 1966, Elton 1958).

3.4 FACTOR 4: Inadequacy of Existing Regulatory Mechanisms

3.4.1 Federal Mechanisms

At the time of listing, several principal federal regulatory and planning mechanisms affected the conservation of steelhead populations within the SCCCS Recovery Planning Area (National Marine Fisheries Service 1996b, 1997a). These included: 1) land management practices within the four U.S. National Forests within the SCCCS Recovery Planning Area (Los Padres, Angeles, San Bernardino, and Cleveland); 2) the regulation of dredging and the placement of fill within the waters of the United States by the U.S. Army Corps of Engineers (USACE) through the Clean Water Act (CWA) Section 404 Program; 3) the regulation of dredging and the placement of fill within the waters of the United States through the CWA section 401 water quality certification regulations; 4) the Federal Emergency Management Agency (FEMA) administration of a Flood Insurance Program which strongly influences the development in waterways and floodplains; and 5) inadequate implementation of the CWA sections 303(d)(1)(C) and (D) to protect beneficial uses associated with aquatic habitats, including fishery resources, particularly with respect to non-point sources of pollution (including increased sedimentation from routine maintenance and emergency flood control activities within the active channel and floodplain).

For example, the USACE's program is implemented through the issuance of a variety of Individual, Nationwide and Emergency permits. Permitted activities should not "cause or contribute to significant degradation of the waters of the United States." A variety of factors, including inadequate staffing, training, and in some cases regulatory limitations on land uses (e.g., agricultural activities) and policy direction, resulted in ineffective protection of aquatic habitats important to migrating, spawning, or rearing 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 404 and 401programs. Additionally, the USACE does not regulate most agricultural activities through administration of the 404 Program.

Similarly, the National Flood Insurance Program regulations allow for development in the margins of active waterways if they are protected against 100-year flood events, and do not raise the water elevations within the active channel (floodway) more than one foot during such flood events. This standard does not adequately reflect the dynamic, mobile nature of watercourses in South-Central California Coast, and the critical role that margins of active waterways (riparian areas) play in the maintenance of aquatic habitats. In addition, FEMA programs for repairing flood related damages (Public Assistance Program, Individual and Households Program, and Hazard Mitigation Grant Program) promote the replacement of damaged facilities and structures in their original locations, which are prone to repeated damage from future flooding, and thus lead to repeated disturbance of riparian and aquatic habitats important to migrating, spawning, or rearing steelhead.

3.4.2 Non-Federal Mechanisms

At the time of listing, several principal non-federal regulatory and planning mechanisms affected the conservation of steelhead populations within the SCCCS Recovery Planning Area (National Marine Fisheries Service 1997a, 1996b). These included: 1) administration of the California State Water Resources Control Board (SWRCB) water rights permitting system which controls utilization of waters for beneficial uses throughout the state; 2) state and local government permitting programs for land uses on non-federal and non-state owned lands; 3) administration of the Fish and Game Code Sections 1600-1603 (Streambed Alteration Agreements) program and 5957-5937

(regulation of dams); and 4) the lack of a Coast-Wide Anadromous Fish Monitoring Plan for California to inform regulatory actions such as angling restrictions. For example, the SWRCB water rights permitting system contains provisions (including public trust provisions) for the protection of instream aquatic resources. However, the system does not provide an adequate regulatory mechanism to implement the CDFG Code Sections 5935-5937 requirements for the owner of any dam to protect fish populations below impoundments. Currently the SWRCB's administrative policy implementing California Water Code Section 1294.4 applies only to northern California counties. Additionally, SWRCB generally lacks the effective oversight and regulatory authority over groundwater development comparable to surface water developments for out-of-stream beneficial uses.

The Section 1600 Lake or Streambed Alteration Agreements program is the principal mechanism through which the CDFG provides protection of riparian and aquatic habitats. 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 migrating, spawning and rearing steelhead.

Additionally, within the SCCCS Recovery Planning Area there is limited institutional organization specifically dedicated to steelhead recovery planning and implementation. Currently, the principal entities include the Tri-Counties Fish Team (which covers Ventura, Santa Barbara, and San Luis Obispo Counties and the state-wide organization, CalTrout; other portions of the SCCCS Recovery Planning Area are the focus of attention of individuals, watershed groups, or agencies with broader responsibilities or interests.

Finally, monitoring of stocks (particularly annual run-sizes) is essential to assess the current and future status of individual populations and the SCCCS DPS as a whole, as well as to develop basic ecological information of the steelhead populations of the SCCCS Recovery Planning Area. However, the Coast-Wide Anadromous Fish Monitoring Plan remains unfinished and funding for its implementation has not been identified and secured.

3.5 FACTOR 5: Other Natural or Human-Made Factors Affecting Continued Existence

This factor category encompasses two specific threats to the species identified at the time of listing: 1) environmental variability and 2) stocking programs. Similar to the other listing factors, these threats persist and recent information about environmental variability, including the effects of ocean conditions on the survival of salmonid populations and increases in wildfire occurrence and severity, indicate that the threat from "environmental variability" can be expected to increase. The current and future threat to species recovery from environmental variation is further discussed in Chapter 4, Current DPS-Level Threats Assessment, and 5, South-Central California Coast Steelhead and Climate Change.

3.5.1 Environmental Variability

Variability in natural environmental conditions has both masked and exacerbated the problems associated with degraded and altered riverine and estuarine habitats. Floods and persistent drought conditions have periodically reduced naturally limited spawning, rearing, and migration habitats.

California Wildfires (Courtesy NASA)

Furthermore, El Nino events and periods of unfavorable ocean-climate conditions 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 returning adults (National Marine Fisheries Service 1996a).

3.5.2 Stocking Programs

There are no steelhead production hatcheries operating in or supplying hatchery reared steelhead to the SCCCS Recovery Planning Area. However, up until the mid to late 1990's steelhead smolts derived from the San Lorenzo River were placed in the anadromous waters of the Pajaro and various tributaries (*e.g.*, Corralitos, Browns Valley, Uvas Creeks) as well as in the Arroyo Seco in the early 1990s.

However, there is a small anadromous *O. mykiss* rearing operation on the Carmel River, and in the past there has also been an anadromous *O. mykiss* rearing operation on Old Creek, Garrapata Creek and a salmon rearing facility operated in connection with San Luis Obispo Creek. Additionally, CDFG maintains a stocking program of hatchery-derived non-anadromous *O. mykiss* in order to support put-and-take fisheries. These stockings are now generally conducted in non-anadromous waters, though fish may enter anadromous waters during spillage at dams. Until recently, CDFG has planted non-native steelhead in anadromous waters in the Nacimiento River, and there are reports of plantings in non-anadromous portions of the Pajaro River prior to the list of the SCCCS DPS (J. Ambrose, personal communication). Other non-native game species, such as smallmouth bass and bullhead catfish, are often stocked into anadromous waters by a variety of public and private entities (California Department of Fish and Game and Fish and Wildlife Service 2010, Leitritz 1970).

While these programs have provided seasonal fishing opportunities, the impacts of these programs on native, naturally-reproducing steelhead stocks is the subject of considerable discussion and active research (Berejikian 2011, Chilcote 2011, Tatara *et al.* 2011a, 2011b, Fraser 2008, Myers *et al.* 2004, California Department of Fish and Game and National Marine Fisheries Service 2001).

Competition, genetic introgression and disease transmission resulting from hatchery introductions may have the potential to reduce the production and survival of native, naturally-reproducing steelhead (Chilcote 2011, Hayes *et al.* 2004, Myers *et al*. 2004). However, genetic investigations of South-Central California Coast steelhead have not detected any substantial interbreeding of native with hatchery reared *O. mykiss* (Abadia-Cardoso *et al*. 2011, Christie *et al*. 2011, Clemento *et al.* 2009, Girman and Garza 2006).

Steelhead Rearing Facility — Carmel River

Stocking to support recreational angling within the SCCS Recovery Planning Area are now generally conducted in non-anadromous waters, though fish in some cases may escape into anadromous waters (California Department of Fish and Game and U.S. Fish and Wildlife Service 2010). Collection of native steelhead for hatchery broodstock purposes has the potential harm small or dwindling natural populations. However, artificial propagation can also, in some situations, play an important role in steelhead recovery through, among other means, preservation of individuals representing genetic resources which would otherwise be lost as a result of local extirpations. See Chapter 6, Steelhead Recovery Strategy, and Chapter 8, Summary of SCCCS DPS-Wide Recovery Actions.

4. Current DPS-Level Threats Assessment

"A widespread trend observed in this Steelhead Recovery Planning Area is severe to very severe degradation of habitat conditions along the mainstems of impaired watersheds, while the upper mainstem and tributaries retain relatively high habitat values for steelhead."

California Coast Steelhead Recovery Planning Area: Threats Assessment
Hunt & Associates 2008

4.0 INTRODUCTION

Anadromous *O. mykiss* in California face significant threats from water and land management practices that have degraded or curtailed freshwater and estuarine habitats, reducing the capability of the species to persist within most watersheds (Moyle *et al.* 2011, 2008). Extensive agricultural development in the Pajaro and Salinas River basins, as well as in segments of the Pismo, San Luis Obispo, and Arroyo Grande Creek basins, have significantly modified and degraded major steelhead-bearing watersheds, particularly their mainstems and estuarine habitats. In addition, given the current status of the species and the degraded condition of many freshwater and estuarine ecosystems, the persistence and recovery of the species may be further threatened by shifts in climatic and oceanographic conditions. See Chapter 5, South-Central California Coast Steelhead and Climate Change.

Table 4-1 summarizes the top-ranked[1] sources of threats across the SCCCS Recovery Planning Area. These were identified as part of the threats assessment performed for watersheds within each BPG. The threat sources with a "very high" or "high" severity ranking within the largest percentage of the watersheds within the SCCCS Recovery Planning Area were dams and surface water diversions, wildfires, and groundwater extraction. Urban development, levees and channelization, and other passage barriers also affect a large percentage of steelhead watersheds in the SCCCS Recovery Planning Area. Finally, while not captured in the threats assessment process that ranked the threats by threat source categories associated with Biogeographic Population Groups, the impacts of environmental variability, including projected changes in precipitation patterns and the consequences of fluctuations in ocean conditions play a significant role in the persistence and recovery of the SCCCS DPS; these are dealt with in Section 4.2.6 and Chapter 5, South-Central California Coast Steelhead and Climate Change.

This chapter provides an introduction to the threats assessment process and summarizes the results of NMFS' threats assessment at the DPS level. Summaries of the threats posed to individual BPGs are presented in the chapters devoted to each BPG.

[1] Threat sources were ranked in terms of the level of contribution and irreversibility of the stressors emanating from the threat source. See Appendix D for further information.

4.1 THREATS ASSESSMENT PROCESS

NMFS assessed the current and expected future threats to the species' persistence and recovery in a set of watersheds identified by the TRT and NMFS staff. This assessment was undertaken with the use of The Nature Conservancy's Conservation Action Planning (CAP) framework. This method and NMFS' application to the threats assessment for South-Central California Coast steelhead is further detailed in Appendix D, South-Central California Coast Steelhead Recovery Planning Area Threats Assessment (CAP Workbooks) method. Use of this method allows NMFS to organize the best available information and professional judgment on the threats facing the species into electronic workbooks that are programmed to summarize and track the information for use in identifying, developing and implementing recovery actions designed to address the identified threats. The threats assessment process is intended to be iterative so that new information can be incorporated as it becomes available or as periodic status reviews of the species occur (Kier Associates and National Marine Fisheries Service 2008a, 2008b, Hunt & Associates 2008a).

Current conditions of essential habitat elements for steelhead were assessed with information from a variety of sources including published and unpublished reports. The severity of threats to steelhead or their habitat was estimated and ranked. Based on the initial threats assessment, the threats and associated sources of those threats across the SCCCS Recovery Planning Area, within each BPG, and within specific watersheds, were identified. A listing of the individual watersheds that were evaluated in the CAP workbooks that were used to summarize threats at these scales can be found in Appendix D.

In addition to the CAP threats assessment process, NMFS considered the best available information regarding the impacts of predicted shifts in climate and the marine environment on the ability of the species to recover. These two threats are not easily addressed in the CAP workbooks and so are not reflected in the tables depicting the threats assessments results below. However, NMFS considered the threats posed by shifting climate and a varying marine environment when recommending a recovery strategy for the species and particular recovery actions. Steelhead will best be able to persist in changing environmental conditions through the recovery of well-distributed viable populations across the SCCS Recovery Planning Area able to support their different life stages and strategies. Recovery actions to address climate and marine environmental conditions are therefore embedded within recovery actions designed to achieve these objectives.

4.2 CURRENT DPS-WIDE THREATS ASSESSMENT SUMMARY

The following discussion presents the available information on the current and future threats faced by the species. The discussion is organized around a set of threat sources identified for each BPG in Chapters 9-12. The information presented in this chapter is a summary of the threats faced by the species across the SCCCS Recovery Planning Area. Specific information on threats within the different BPGs is presented in BPG-specific chapters 9-12 and associated appendices.

The general current conditions of 27 major watersheds within the SCCS Recovery Planning Area ranged from "Fair" to "Poor" at the northern and southern ends of the SCCCS Recovery Planning Area, whereas habitat conditions were generally rated as "Good" or "Very Good" in the central portion of the Recovery Planning Area within the Big Sur Coast and northern San Luis Obispo Terrace BPGS (See CAP Workbook summaries for more detailed information).

Table 4-1. High or Very High severity threat sources identified for the South-Central California Coast Steelhead Recovery Planning Area by BPG.

THREAT SOURCE*	Biogeographic Population Group (BPG)			
	Interior Coast Range	Carmel River Basin**	Big Sur Coast	San Luis Obispo
Dams and Surface Water Diversions	100%	100%	14%	50%
Groundwater Extraction	71%	100%	14%	58%
Levees and Channelization	43%	100%	0%	50%
Recreational Facilities	29%	100%	14%	25%
Urban Development	29%	100%	0%	25%
Roads and Culverts (Other Passage Barriers)	14%	100%	29%	8%
Agricultural Development	71%	0%	0%	67%
Non-Point Pollution	0%	0%	29%	33%
Mining	50%	0%	0%	0%

** Percentages indicate the proportion of all the watersheds in each BPG where the severity of a given threat source was identified as "High" or "Very High" as part of the CAP Workbook analyses. See individual BPG Threat Summaries in Chapters 9-12 for threats ranking in individual watersheds.*
*** The Carmel River is the only watershed within the Carmel River Basin Biogeographic Population Group.*

Many of the watersheds contain high-quality spawning and rearing habitat, but are compromised by one or more anthropogenic factors; for example, Salinas River (San Antonio, and Nacimiento Dams), Carmel River (San Clemente and Los Padres Dams, other passage barriers), and Pajaro River and tributaries (groundwater extraction, flood control, and diversions in the lower reaches) in the Interior Coast Range BPG. A widespread trend observed in the SCCCS Recovery Planning Area is severe to very severe degradation of habitat conditions along the mainstem of impaired watersheds, while the upper mainstem and tributaries (above and below dams) retain relatively high habitat values for steelhead. This is particularly evident in the Pajaro River, Salinas River, and Arroyo Grande Creek watersheds. Another DPS-level threat is impacts associated with wildland fires, including fire-fighting measures to control or extinguish them, and the post-fire measures to repair damages incurred in fighting wildland fires. (See for example, Cooper 2009,

Capelli 2009, National Marine Fisheries Service 2008b, Finger 1997).

4.2.1 Dams, Surface Water Diversions, and Groundwater Extraction

Dams, surface water diversions, and groundwater extraction are common across the SCCCS Recovery Planning Area, especially on the larger rivers, such as the Pajaro, Salinas (and major tributaries, San Antonio and Nacimiento), and Carmel Rivers, but also Old, Pismo, and Arroyo Grande Creeks (California Department of Fish and Game 2011b, California Department of Water Resources 1988). Loss of surface flows or other passage impediments along the mainstem of the river adversely affect the productivity of important upstream tributaries otherwise providing spawning and rearing habitat for anadromous steelhead. Re-establishing or maintaining connections between the ocean and upper watersheds expands access to historically important spawning and rearing habitats, and improves the overall habitat conditions (amount and complexity) for steelhead, as well as the existing populations of native residualized *O. mykiss* that currently are isolated above dams and reservoirs.

San Clemente Dam –Carmel River

Dams also negatively affect the hydrology, sediment transport processes, and geomorphology of the affected drainages. In addition, dams and reservoirs frequently include recreational development for fishing and camping, which can introduce non-native predators and/or competitors (*e.g.*, largemouth and smallmouth bass, carp, crayfish, western mosquitofish) as well as promote trampling of the active channel, which potentially can lead to direct loss of redds (Muhlfeld *et al.* 20011a, 2011b, Johnson *et al.* 2008, Keefer 2008, Caudill *et al.* 2007, Dickens *et al.* 2007, Malcolm *et. al.* 2003, Williams and Bisson 2002, Brandt 2000, Pacific States Marine Fisheries Commission 1999, National Marine Fisheries Service 1996a, Roberts and White 1992).

4.2.2 Agricultural and Urban Development, Roads, and Other Passage Barriers

Human population density is high in some parts of the SCCCS Recovery Planning Area and development pressures in general are concentrated in the coastal terraces and middle and lower portions of watershed. Population density is a relative measure of intensity of land use and impacts to individual watersheds. Some of the watersheds in the Interior Coast Range BPG have been extensively developed for agriculture, which typically utilizes floodplains. In addition, the upland slopes in several of the watersheds in the San Luis Obispo Terrace BPG are extensively planted in orchard crops (California Department of Water Resources 1978).

Agricultural Activity –Pismo Creek

The typical pattern of urban and agricultural development focuses on the flatter portions of a watershed, typically within the floodplain and usually along the mainstem of the drainage and one or more tributaries, thereby magnifying potential impacts to steelhead even if most of the watershed remains undeveloped. Agricultural development on lower floodplains has resulted in channelization, removal of riparian vegetation, and simplification of channel structures, as well as the elevation of fine sediments and other types of pollution such as pesticides and fertilizers which can elevate nutrient levels and increase bio-oxygen demands. Public ownership of lands in the SCCCS Recovery Planning Area varies widely between watersheds but generally decreases southward. Although public ownership of these watersheds (U.S. National Forest and BLM lands, military reservations, *etc.*) can be extensive, these public lands are typically concentrated in the upper watersheds leaving the middle and lower watersheds subject to private development (Kier Associates and National Marine Fisheries Service 2008a, 2008b, Hunt & Associates 2008a, United States Army 2007, United States Forest Service 2005a, 2005b, 2004, National Marine Fisheries Service 1996a).

4.2.3 Flood Control, Levees, and Channelization

Urban and agricultural conversion of floodplain lands adjacent to the mainstem of rivers and streams frequently requires levees or other structures to protect these lands from flooding. The urban and agricultural reaches of a majority of the watersheds in the SCCCS Recovery Planning Area have been subjected to some degree of channelization and/or levee construction with the resulting loss or degradation of the riparian corridor and streambed. Flood control practices and associated channelization of streams and placement of levees impair the function and quality of stream habitats (Jeffres *et al*. 2008, Brown *et al.* 2005, National Marine Fisheries Service 1996a, Faber *et al.* 1989). Extensive channelization has occurred along the Pajaro River, and a number of its tributaries, as well as along the lower Salinas River which has been realigned, and long portions of the Carmel River, Pismo, San Luis Obispo, and Arroyo Grande Creeks (Kier Associates and National Marine Fisheries Service 2008a, 2008b, Hunt & Associates 2008a).

Channelization – Pajaro River

Habitat impairments for *O. mykiss* may include increased water temperature, incision of the streambed and loss of structural complexity and instream refugia (meanders, pools, undercut banks, *etc.*), complete loss of bed and bank habitat, increased sedimentation, turbidity, and substrate embeddedness, and excessive nutrient loading (Richardson, *et al.* 2010, Jeffres *et al.* 2008, Naiman *et al.* 2005, Newcombe 2003, National Research Council 2002, Naiman and Bilby 1998, Capelli and Stanley 1984, Warner and Hendrix 1984, Newcombe and McDonald 1991).

4.2.4 Non-Native Species

Non-native game species, such as large and smallmouth bass white bass, and bullhead catfish, are often stocked into both non-anadromous and anadromous waters by a variety of public and private entities. Additionally other non-native species such as striped bass have spread into some of the watersheds of the SCCC Recovery Planning Area from other areas. While these programs have provided seasonal fishing opportunities, the impacts of these programs on native, naturally-reproducing *O. mykiss* stocks are not

well understood, though there is a potential adverse impact as a result of predation, disease, disruption of behavior or habitat displacement Cucherousset and Olden 2011, Davis 2009, Fraser 2008, Fritts and Pearsons 2006, Hayes *et al.* 2004, Noga 2000, Wood 1979, Dill and Cordone 1997, National Marine Fisheries Service 1996a, Rucker and Ordall 1953).

There are no production steelhead hatcheries operating in or supplying hatchery reared steelhead to the SCCCS DPS. However, there is an extensive stocking program of hatchery cultured and reared, non-anadromous *O. mykiss* (*i.e.,* rainbow trout) that supports a put-and-take fishery. Competition and disease transmission resulting from hatchery introductions have the potential to reduce the production and survival of native, naturally-reproducing steelhead, though genetic investigations of South-Central California Coast steelhead have not detected any substantial interbreeding of native with hatchery reared *O. mykiss* (Clemento *et al.* 2009, Girman and Garza 2006). These stockings are now generally conducted in non-anadromous waters.

However, California's steelhead stocking practices have distributed non-native steelhead stocks in many coastal rivers and streams in California (California Department of Fish and Game and U.S. Fish and Wildlife Service 2010). Because of problems associated with the practice of transplanting non-native steelhead stocks, CDFG developed its Salmon and Steelhead Stock Management Policy. This policy recognizes that such stock mixing can be detrimental and seeks to maintain the genetic integrity of all identifiable stocks of salmon and steelhead in California, as well as minimize interactions between hatchery and natural populations. To protect the genetic integrity of individual salmon and steelhead stocks, this policy directs CDFG to evaluate the stocks of each salmon and steelhead stream and classify it according to its probable genetic source and degree of integrity (McEwan and Jackson 1996). Additionally, CDFG has eliminated the stocking of hatchery cultured and reared fish in most coastal streams where steelhead have direct access from the ocean (California Department of Fish and Game and U.S. Fish and Wildlife Serviced 2010).

Striped Bass - Pajaro River (Courtesy Joel Casagrande)

In addition to the intentional introduction of non-native game species of fish, many other non-native species of wildlife and plant species have been introduced into the watersheds of South-Central California Coast which have the potential to displace native species, or adversely affect aquatic habitat conditions. Invasive plants such as the Giant reed *(Arundo donax)* and Tamarisk (*Tamarix* spp.) currently displace extensive areas of native riparian vegetation in major drainages such as the Salinas River and, in some cases, can reduce surface flows through the uptake of large amounts of groundwater. Non-native plant species such as water primrose (*Ludwigia uruguayensis*) can displace aquatic living space and, in extreme conditions, inhibit or block the instream movement of fish. Non-native plants can also reduce the natural diversity of insects that are important food sources for juvenile *O. mykiss* (Bell *et al.* 2009, Bossard *et al.* 2000, McKnight 1993).

4.2.5 Estuarine Loss

The mouths of most South-Central California Coast watersheds are characterized by one of several distinct types of estuaries formed by a combination of coastal topography, geology, and the hydrologic characteristics of the watershed (Jacobs *et al.* 2011, Ferren *et al.* 1995). Estuaries are used by steelhead as rearing areas for juveniles and smolts as well as staging areas

for smolts acclimating to saline conditions in preparation for entering the ocean and adults acclimating to freshwater in preparation for spawning (Kier Associates and National Marine Fisheries Service 2008a, 2008b).

Estuarine Fill- Pajaro River

Because estuaries are located at the downstream end of coastal watersheds, and on relatively level coastal plains which are the most heavily urbanized portions of South-Central California, they have been subjected to a majority of the DPS-wide threats identified through the threats assessment. Estuarine functions have been adversely affected in a wide variety of ways (*e.g.*, degradation of water quality, modification of hydrologic patterns, changes in species composition). One indicator of the magnitude of the loss of estuarine functions is loss of wetland acreage, through a range of activities, including filling, diking, and draining. Approximately 75 percent of estuarine habitats across the SCCCS Recovery Planning Area have been lost and the remaining 25 percent is constrained by agricultural and urban development, levees, and transportation corridors highways and railroads (primarily in more extensively developed northern and southern portions of the SCCCS Recovery Planning Area). Grossinger *et al.* (2011), Kier Associates and National Marine Fisheries Service (2008a, 2008b), Dahl (1990), Ferren *et al.* (1995). In addition to the loss of overall acreage the habitat complexity and ecological functions of South-Central California Coast estuaries have also been substantially reduced as a result of the loss of shallow-water habitats such as tidal channel, the degradation of water quality through both point and non-point waste discharges and the artificial breaching of the seasonal sandbar at the estuaries mouth which can reduce and degrade steelhead rearing habitat. Estuarine habitat loss varies widely across BPGs, with the Pajaro and Salinas estuaries experiencing the largest physical modification and the estuaries along the Big Sur Coast (.e.g., Little Sur and Big Sur River) and the northern portion of the San Luis Obispo County coast (*e.g.,* San Carpoforo, Arroyo de la Cruz, and Little Pico Creek) the most physically intact, though they are impaired by reduced freshwater inflows and point and non-point waste discharges.. Table 4-2 provides an estimate of the relative loss of South-Central California Coast wetland estuarine acreage for some of the estuaries associated with steelhead populations in South-Central California Coast for which information was available. See Chapter 2, Steelhead Biology and Ecology for a discussion of the role of estuaries in the life history of steelhead.

Table 4-2. Estuarine habitat loss in component watersheds of the South-Central Coast Steelhead Recovery Planning Area by BGP.[1]

BPG	Watershed	Remaining Estuarine Habitat (% of historical habitat)
Interior Coast Range	Pajaro River	15
	Salinas River	10
Carmel River Basin	Carmel River	67
Big Sur Coast	San Jose Creek	10
	Garrapata Creek	100
	Bixby Creek	100
	Little Sur River	100
	Big Sur River	100
	Willow Creek	70
	Salmon Creek	100
San Luis Obispo Terrace	San Carpoforo Creek	90
	Arroyo de la Cruz	90
	Little Pico Creek	100
	Pico Creek	60
	San Simeon Creek	50
	Santa Rosa Creek	62
	Morro Creek	0
	Chorro and Los Osos creeks	83
	San Luis Obispo Creek	60
	Pismo Creek	30
	Arroyo Grande Creek	20

[1] Adapted from Kier Associates and National Marine Fisheries Service (2008a, 2008b).

4.2.6 Marine Environment Threats

Steelhead spend a majority of their life history cycle in the marine environment. Unlike the other anadromous Pacific salmon in the genus *Oncorhynchus*, steelhead do not die after entering freshwater to spawn, but may return to the marine environment and complete another year of ocean growth before returning to freshwater to repeat their reproductive cycle. Steelhead have not been observed in the marine environment in large aggregating schools with well-defined ocean migratory patterns. The incidental capture of steelhead in the marine environment as a by-catch of commercial fishing activities is uncommon. As a result of the apparent dispersal of single individuals or small groups in the marine environment, information on the movements, feeding habits, and predator-prey relationships of steelhead has not been extensively studied and is not well understood (Grimes *et al*. 2007, Aydin *et al.* 2005, Burgner *et al*. 1992, 1980, Groot and Margolis 1991, Hartt and Bell 1985). Table 4-3 outlines some of the metrics which are relevant to assessing conditions in the marine environment for both sub-adult and adult steelhead, though the actual conditions are either highly variable, or unknown.

Table 4-3. South-Central California Coast Steelhead Marine Environment Threats Assessment.

South-Central California Coast Steelhead Marine Environment Threats Assessment								
1. Sub-Adult Steelhead								
Category	**Key Attribute**	**Indicator**	**Poor**	**Fair**	**Good**	**Very Good**	**Current Indicator Status**	**Current Rating**
Landscape Context	Habitat Availability	Vegetation density in nearshore marine areas of CA – e.g., kelp/hectare	Low kelp density		High kelp density		Baseline data unavail-able	Variable
Landscape Context	Oceano-graphic Conditions	Ocean production index	Poor ocean conditions		Good ocean conditions			Variable
Condition	Fish Health	Condition of factor of sub-adult conspecifics collected in seines or other surveys	Data unavailable					Unknown
Condition	Fish Health	Incidence of disease/ parasitism in sub-adult conspecifics; salmon obtained from seine or other surveys	Baseline data unavailable					Unknown
Condition	Food Availability	Upwelling index	Poor ocean conditions		Good ocean conditions			Variable

Condition	Variability in Run Timing	Proportion of # of current vs. historic life history variations represented in domain	25% or less of historically known variation in run timing preserved in current runs	50% of historically known variation in run timing preserved in current runs	75% of historically known variation in run timing preserved in current runs	All historically known variation in run timing preserved in current runs		Unknown
2. Adult Steelhead								
Category	**Key Attribute**	**Indicator**	**Poor**	**Fair**	**Good**	**Very Good**	**Current Indicator Status**	**Current Rating**
Landscape Context	Oceano-graphic conditions	Ocean Production Index	Poor ocean conditions		Good ocean conditions			Variable
Condition	Fish Health	Condition factor of ocean-intercepted conspecifics	Data unavailable					Unknown
Condition	Fish Health	Incidence of disease/ parasitism in ocean-intercepted conspecifics	Baseline data unavailable					Unknown
Condition	Food Availability	Upwelling Index	Poor ocean conditions		Good ocean conditions			Variable
Condition	Variability in Run Timing	Proportion of # of current vs. historic life history variations represented in domain	25% or less of historically known variation in run timing preserved in current runs	50% of historically known variation in run timing preserved in current runs	75% of historically known variation in run timing preserved in current runs	All historically known variation in run timing preserved in current runs		Unknown

4.2.7 Natural Environmental Variability

Natural environmental variation has exacerbated the problems associated with degraded and altered riverine and estuarine habitats. See discussion in Chapter 2, Steelhead Biology and Ecology, Section 2.6. The current climate of the SCCCS Recovery Planning Area is classified as Mediterranean. This climatic regime is characterized by two distinct annual seasons, with a high degree of inter-annual and decadal variability: a long rainless season extending from May through November and a brief rainy season from December through March. Rainfall is associated with brief, but intense, cyclonic winter storms. This region is also subject to an El Niño/La Niña weather cycle which varies in length from seven to ten years. This large-scale weather pattern can significantly affect winter precipitation, causing highly variable rainfall and significant changes in oceanic conditions between years (McMullen and Jabbour 2010, Intergovernmental Panel on Climate Change 2007a, Changnon 2000, Philander 2004, 1990). In addition to these temporal climatic patterns, there is a wide disparity between winter rainfall from north to south, as well as between coastal plains and inland mountainous areas. Annual precipitation ranges along the coast (north to south) from 32 to 24 cm, with larger variations (24 – 90 cm) due to the orographic effects of the various mountain ranges, and well as El Nino-Southern Oscillation (Castello and Shelton 2004, Felton 1965).

River discharge, and therefore freshwater habitat conditions within South-Central California Coast watersheds, is strongly influenced by the intra- and inter-annual pattern of short-duration cyclonic storms (*e.g.*, frequency, timing, intensity, and duration). As a result, river discharge varies greatly between seasons, and can be highly "flashy" during the

winter season, sometimes changing by several orders of magnitude over a few hours. Snow accumulation is generally small and of short duration, and does not contribute significantly to peak run-off. Base flows in some river reaches can be influenced significantly by groundwater stored and transported through alluvium, faults, and fractured rock formations. Many rivers and streams naturally exhibit interrupted base flow patterns (alternating channel reaches with perennial and seasonal surface flow) controlled by geologic formations, and the strongly seasonal precipitation pattern characteristic of a Mediterranean climate (Boughton *et al.* 2009, 2006, Holland 2001, Mount 1995, Jacobs, *et al.* 1993, Faber *et al.* 1989).

Over the course of their life cycle steelhead occupy both freshwater and marine environments. Freshwater habitats are critical for their reproductive phase, providing suitable habitat for the deposition, fertilization, and incubation of eggs in nests (redds) created by adults in spawning gravels. Freshwater habitats also provide a sheltered environment, relatively free of native predator species, and with suitable food sources, for rearing juveniles. Marine habitats are important for the growth and maturation of sub-adults, providing more abundant and appropriately sized food sources to support the large numbers of maturing fish emigrating from coastal watersheds of the South-Central California Coast Steelhead Recovery Planning Area, as well as fish originating from other coastal watersheds of the North Pacific Watershed (Quinn 2005, Moyle 2002). Both freshwater and marine environments are affected by weather and climatic conditions that vary on time scales ranging from hours to millennia. Despite the highly mobile nature of steelhead, and their ability to exploit freshwater and marine habitats in multiple ways, they remain vulnerable to natural changes in their environment.

4.2.8 Pesticide Use

The extensive use of pesticides for commercial agricultural purposes and there effects on anadromous salmonids has become an increasing area of concern (Baldwin *et al.* 2010, Macneale *et al.* 2010). Pesticide is a general term that refers to a wide range of chemicals (natural or anthropogenic in origin) or elements (such as copper sprays) used in an application with the intent to control or kill a pest species. Common classes of pesticides include insecticides, rodenticides, fungicides and herbicides. Pesticides may affect listed salmonids through direct or indirect means, via lethal or sub-lethal effects, over short time periods (acute effects) or longer time periods (chronic effects) or through the alteration of critical habitat components resulting in harm to the listed salmonids (Baldwin *et al.* 2010, Macneale *et al.* 2010). Adjuvants to pesticide active *ingredients*, such as surfactants or spreaders, may also cause or contribute to these effects (Laetz 2009).

Pesticides may also benefit listed salmonids, when used properly, in projects that protect or restore habitat functions such as the removal of non-native species (California Department of Pesticide Regulation 2012b, Zhang and Goodhue 2010). Several of the watersheds within the SCCC Recovery Planning (*e.g.,* Pajaro, Salinas, Santa Rosa, and Arroyo Grande) have been developed extensively with commercial agriculture, particularly row crops which are subjected to regular applications of a variety of pesticides. The nature and extent of the short and long-term effects of these pesticides on particular populations of steelhead within the SCCC Recovery Planning Area has not been extensively studied, and consequently is not well known. NMFS is working with the EPA at the national level to address EPA's responsibilities under the ESA during the process of registering or reregistering pesticide active ingredients for use under the Federal Insecticide, Fungicide, and Rodenticide Act and for establishing water quality criteria for

pesticides under the Clean Water Act. At the Regional level, NMFS works with the State of California and EPA Region IX to assess these water quality criteria as they are proposed. NMFS also works with numerous action agencies or organizations to review or help plan their pesticide application projects for protectiveness to ESA listed species and their habitats.

5. South-Central California Coast Steelhead and Climate Change

"The West Coast's salmon and steelhead populations have always been sensitive to the variability of the northeast Pacific climate-ocean system . . . So steelhead recovery as a form of human stewardship has to be judged over a broader timeline, with multi-year setbacks in population size considered to be a normal and expected event, and progress judged at the scale of multiple decades and even multiple human generations."

Dr. David A. Boughton, Chair, NOAA Fisheries South-Central/Southern California Steelhead Technical Recovery Team, 2010

5.0 INTRODUCTION

The addition of CO_2 and other greenhouse gasses to the atmosphere over the past two centuries, as a result of industrialization and changes in land use, has substantially altered the radiative balance of the Earth. Less of the energy entering the Earth's atmosphere as sunlight is being re-radiated to space, with the effect that the planet is currently heating up at a pace not seen in human history, and perhaps not for millions of years (Archer and Pierrehumbert 2011, Solomon *et al.* 2009, Archer 2007).

The potential physical effects of projected future climate changes are manifold and complex, varying in range and intensity, across various landscape scales and ecosystem types. The biological response is also complex, and with many species, including Pacific anadromous salmonids, uncertain. While South-Central California Coast steelhead have evolved a suite of historically effective adaptations to a highly variable environment (including multiple paths for completing their life cycle), the rapid rate of projected climate presents yet another challenge to their persistence. Recent assessments of global climate change and climate change in the United States summarize the general effects on ecosystems (Trenberth, *et al*. 2011, Johnstone and Dawson 2010, Cayan, *et al*. 2009, Dettinger, *et al*. 2009, Mastrandera *et al.* 2009, Medellin-Azuara *et al.* 2009, Shaw *et al.* 2009, Westerling *et al.* 2009, Backland *et al.* 2008, Bedworth and Hanak 2008, and Gutowski *et al*. 2008, Barbour and Kueppers 2008, Hanak and Moreno 2008, Hanak and Lund 2008, Luers and Mastrandrea 2008,

Intergovernmental Panel on Climate Change 2007a, 2007b).

These general physical effects include: 1) warmer atmospheric temperatures; 2) rises in sea level due to ice cap melting and thermal expansion of ocean water; 3) acidification of ocean waters; 4) increased droughts (frequency, severity, and duration) coupled with more severe cyclonic storms (intensity and duration); 5) increases in the intensity, frequency and duration of wildland fires; 6) modification of a variety of watershed processes, including run-off, erosion, sedimentation, and a variety of hill-slope processes ranging from ravel to mass-wasting and debris flows; 7) increases in water temperatures in rivers and streams; and 8) alterations in stream morphology (*e.g.*, occurrence and distribution of sediments, pools, riffles, etc.) as a result of changes in the frequency and intensity of high-flow events.

A review of existing studies indicates that regional climate changes would drive ecosystem changes in diverse ways (Dawson *et al*. 2011, Schwing *et al.* 2010). The ability to model and forecast the effects of such changes on steelhead populations is likely to be quite limited due to limitations on the predictability of behavior of non-linear causal networks (Schindler *et al.* 2008). This problem is common to many threatened and endangered species, but is exacerbated for Pacific salmonids due to their requirements for a succession of different habitats over the course of their life history cycle. However, the environmental changes anticipated for South-Central California Coast steelhead are not as profound as other regions of California. For example, in the Central Valley anadromous fish populations dependent on snowmelt-fed river systems may undergo a conversion to rain-fed systems, or along the central and north coastal areas where coho populations which have a fixed life history strategy may be less adaptable to environmental changes than steelhead (Moyle *et al.* 2008).

The projected climate changes in South-Central California are expected to mainly intensify patterns that are characteristic of a semi-arid Mediterranean Climate (periodic droughts, intense cyclonic rainstorms, dry, hot summers) and to which South-Central Coast populations of steelhead appear to have already evolved a flexible, opportunistic survival strategy. An important factor for coastal populations is the continuing role of the ocean in moderating coastal climates due to its high heat capacity. Thus coastal steelhead populations, even in the South-Central portions of California, appear to have a more predictable future than inland populations which are vulnerable to faster and more extreme changes in climate (Boughton 2010a).

5.1 PROJECTED CLIMATE CHANGES

5.1.1 Terrestrial and Freshwater Environment

Geographically, California is situated at the transition between regions of net gain and net loss of water, and predicted future water availability is sensitive to model assumptions and emissions scenarios (Hayhoe *et al*. 2004). Climate models appear to make a median prediction of about 10% loss of precipitation statewide by 2100, under a low emissions scenario (Cayan *et al*. 2009). However, there is enough variability in the predictions that significantly drier or wetter futures are also reasonable expectations (Trenberth *et al*. 2011, Hayhoe *et al*. 2004, Leung *et al*. 2004, Snyder *et al*. 2002).

For California, the mid-century (2035- 2064) response to global climate change is

consistent across scenarios: an annual maximum temperature increase of about +1.9° to +2.3°C for sensitive climate models, and 1°C less for the less sensitive model (Shaw *et al.* 2009). The statewide precipitation response is relatively small, ±4cm across the various scenarios and models, though more precipitation falls as rain rather than snow. Also, the snow melts sooner; and more is evaporated leading to lower soil moisture and streamflows (Null *et al.* 2010, Cayan *et al.* 2008a). The model simulations suggest that predictability is reasonably good at the 40-year time-scale, perhaps because global climate outcomes at this timescale are dominated not by positive atmospheric feedbacks, but by the inertial effect of the ocean, which acts as transient negative feedback that limits the pace of climate change (Baker and Roe 2009).

By 2100 the temperature scenarios diverge much more severely, about +2.5°C versus +4.2°C for the lower and middle-upper emission scenarios, respectively. Under the middle-upper emission scenario, the end-of-the-century also marks a period of unprecedented wildfires and significantly more erratic precipitation in the south-central and southern coastal regions, and the possibility of large decreases in mean precipitation (Shaw *et al.* 2009, Cayan *et al.* 2008a).

Perhaps more importantly, under the middle-upper emission scenario, the end-of-the-century marks a period of *accelerating* greenhouse gas emissions and climate change, whereas in the lower scenario it is a period of emissions *shrinking* toward zero and global change that is decelerating toward equilibrium (Solomon *et al.* 2009, Cayan *et al.* 2008a). Thus the changes projected under the middle-upper emissions scenario are the prelude for even faster changes in the 22nd Century, with no prognosis for stabilizing greenhouse gas concentrations and climate.

Regional climate projections for the south-central and southern California coast ranges suggest a future of longer, hotter summers, but with a potentially higher incidence of fog along the immediate coast, more extreme heat waves and droughts, but with perhaps more intense precipitation events in some areas (Karl *et al.* 2009, Cayan *et al.* 2008a, Snyder and Sloan, 2005, Snyder *et al.* 2002).

Climate change has the potential to profoundly affect both terrestrial and freshwater ecosystems in California (Maurer *et al.* 2010, Bakke 2008, Barbour and Kueppers 2008, Schindler *et al.* 2008). There are a number of potential negative effects on steelhead and their freshwater and estuarine habitats which are of particular significance. Many of these effects could be exacerbated by the human response to climate change, particularly as a result of the increase competition for limited freshwater supplies. These are summarized below (Schwing *et al.* 2010).

Rainfall and Runoff. Steelhead depend on adequate rainfall and run-off during their migratory seasons to both enter and emigrate from coastal watersheds. In South-Central California adequate stream flow is not only necessary for adults to reach upstream spawning areas and juveniles to emigrate to the ocean, but also to breach the sand bar, which seasonally forms at the mouth of most coastal rivers and streams, to allow entrance to and emigration from the watershed (Jacobs *et al.* 2011, Maurer 2006, Quinn 2005).

Rivers and riparian areas (and associated wetland areas) make up less than one percent of the landscape in arid regions such as South-Central California. These highly productive ecosystems are embedded within upland systems with much lower productivity. The primary driver of

terrestrial hydrologic systems is precipitation. Most of the United States experienced increases in precipitation and stream flow and decreases in drought during the second half of the past century. However, there are indications that increases in the severity and duration of droughts have increased in the western and southwestern United States. The full effects of these changes on aquatic organisms such as *O. mykiss* are not well understood (Schwing *et al.* 2010).

Groundwater. Groundwater is an important source of surface flows during dry periods in many South-Central California Coast watersheds. Groundwater can therefore contribute to sustaining suitable over-summering juvenile rearing conditions in mainstem and tributary habitats. Surface flows can be maintained as a result of the intersection of a high groundwater table or through the transmission of water through geologic fault systems. The effects of climate change on groundwater systems have not been as extensively studied as have the effects of climate change on surface water systems. One recent investigation in the Santa Ynez Mountains of California suggests that an increase in the biomass of watersheds dominated by chaparral is likely to increase with the increase of atmospheric CO_2 and atmospheric temperature, leading to reductions in summer stream flow (Tague *et al.* 2009). Other Global Climate Models (GCMs) projecting a decrease in vegetative cover could lead to an increase in summer stream flow (Boughton 2010a).

Water Temperature. Increased minimum atmospheric temperatures and warmer spring and summer temperatures have led to increased stream temperatures in most of the continental Unites States. Increased stream temperatures likely will have both direct and indirect adverse impacts on juvenile *O. mykiss.* These include subjecting the species to physiological stress, and altering the aquatic environment through such modifications as reducing dissolved oxygen levels or increasing the growth of algae and rooted aquatic vegetation. Elevated stream temperatures can also favor the proliferation of non-native warm water species that can compete for living space, and also prey on native *O. mykiss*, particularly juveniles. Changes in water temperature are most likely to occur during low-flow periods that coincide with over-summering rearing juvenile *O. mykiss*. Stream temperature increases have already begun to be detected across the United States, though no comprehensive analysis similar to streamflow trends has been conducted. An increase in the incidence of coastal fog could moderate these effects in some coastal areas (Wenger *et al.* 2011, Johnstone and Dawson 2010, Mantua *et al.* 2010, Keefer 2009, Schindler *et al.* 2008, Daufresne and Boet 2007, Battin 2007, Mohseni and Eaton 2003, Mohseni et al. 1999a, 1999b, Eaton and Schaller 1996).

Wildland Fire. Chaparral is the predominant vegetation type within the SCCS Recovery Planning Area. Wildfires are a natural phenomenon essential for the periodic renewal of chaparral plant communities (Sugihara *et al.* 2006, Davis and Borchert 2006). In addition, wildfires can have at least temporary major impacts on freshwater habitats of anadromous and non-anadromous *O. mykiss.* These effects range from increasing the erosion, transportation, and deposition of massive amounts of fine sediments into watercourses containing coarser-grained spawning gravels to destroying riparian vegetation and facilitating the spread of non-native plant and animal species. The frequency and size of wildfires is expected to increase as a result of increases in atmospheric temperatures (Bell *et al.* 2009, Westerling and Bryant 2008, Westerling *et al.* 2009,

Lenihan *et al*. 2006, Miller and Schlegel 2006).

Santa Ana winds and human-triggered ignitions play important roles in the fire regime of South-Central California chaparral and scrubland forests. These seasonal, hot, dry winds occur primarily during the fall and winter and are driven by large-scale patterns of atmospheric circulation resulting from high pressure over the Great Basin, coupled with low pressure off the coast of South-Central California that drives dry air toward the coast. These winds can reach 40 miles per hour and can spread fires rapidly, sometimes burning 115 square miles of chaparral and shrub vegetation per day (Ryan and Burch 1992). Using GCMs, Miller and Schlegel (2006) predict that the total number of annual Santa Ana wind events would not change over the next 30 years, though one of the General Climate Model simulations showed a shift in the seasonal cycle, with fewer Santa Ana wind events occurring in September and more occurring in December. The potential implications of this shift for the fire regime are unclear (Davis and Borchert 2006, Keeley 2006, Keeley *et al.* 1999). Wildland fire impacts can be compounded by fire-fighting measures to control or extinguish wildland fires (*e.g.*, the use of fire retardants) as well as by post-fire measures to repair damages incurred in fighting wildland fires
(Capelli 2009, Cooper 2009, National Marine Fisheries Service 2008b, Finger 1997).

5.1.2 Marine Environment

Steelhead spend the majority of their lives in the marine environment, entering freshwater habitats for brief periods to reproduce and rear. While steelhead are subjected to the same basic oceanic conditions (*e.g.*, currents, water temperature, up-welling, abundance of prey base, predator-prey interactions, and water quality) as other anadromous Pacific anadromous salmonids, they may respond and be affected by such conditions differently because of their distinctive behavioral, physiological and other ecological characteristics. However, as with other anadromous Pacific salmon, conditions in the marine environment are crucial to the growth, maturation, mortality, and abundance of returning adult steelhead to their freshwater spawning habitats.

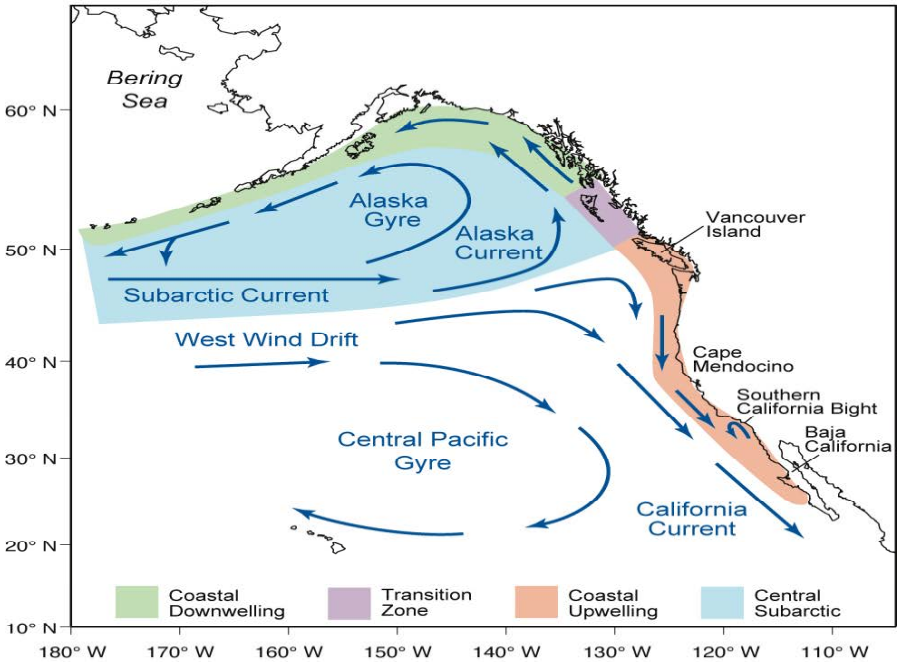


Fig. 5-1. Principle Ocean Currents in the North-East Pacific Ocean Affecting Coastal Waters of California (J. A. Barth, Oregon State University

California Current Ecosystem. The California Current Ecosystem (CCE) is one of eight large marine ecosystems within the jurisdiction of the United States. The northern end of the current is dominated by strong seasonal variability in winds, temperature, upwelling, plankton production and the spawning times of many fishes, whereas the southern end of the current has much less seasonal variability. Climate signals in this region are quite strong. During the past 10 years, the North Pacific has seen two El Niño events (1997/98, 2002/03), one La Niña event (1999), a four-year climate regime shift to a cold phase from 1999 until late 2002, followed by a four-year shift to warm phase from 2002 until 2006 (Schwing *et al*. 2010, Peterson and Schwing 2003, Mantua *et al.* 1997). However, because of the dearth of information on the marine phase of steelhead it is difficult to assess the biological response to projected climate driven changes in the CCE.

Climate-Induced California Current Ecosystem Responses

Numerous climate stressors (*e.g.,* warming, sea level rise, freshwater flow) impact productivity and structure throughout the CCE. The following provides a summary of these issues based upon the analysis developed as part of a NMFS framework for a long-term plan to address climate impacts on living marine resources (Schwing *et al.* 2010, Osgood 2008).

1. Future climate variability in the context of global climate change and a warmer planet

One of the likely consequences of global climate change will be a more volatile climate with greater extreme events on the intra-seasonal to inter-annual scales. For the CCE this will mean more frequent and severe winter storms, with greater wind mixing, higher waves and coastal erosion, and more extreme precipitation events and years, which would impact coastal circulation and stratification. Some global climate models predict a higher frequency of El Niño events; others predict that the intensity of these events will be stronger. If true, primary and secondary production will be greatly reduced in the CCE, with negative effects transmitted up the food chain, including to the Pacific anadromous salmonids (Trenberth *et al.* 2010, Mastrandrea *et al.* 2009, Karl *et al*. 2008, Bell and Sloan 2006, Benestad 2006, Bell *et al.* 2004, Trenberth 1999).

2. The extent and timing of freshwater input and its impact on the nearshore habitat of anadromous fishes

Variability in ocean conditions has substantial impacts on salmon survival and growth, and can be influenced in continental shelf waters by river runoff. Potential changes in rainfall and snow pack are likely to increase winter and spring runoff but decrease summer runoff. Climate models project the 21st century will feature greater precipitation in the Pacific Northwest, extreme winter precipitation events in California, and a more rapid spring melt leading to a shorter, more intense spring period of river flow and freshwater discharge. This will greatly alter coastal stratification and mixing, riverine plume formation and evolution, and the timing of transport of anadromous populations to and from the ocean (Maurer *et al*. 2010, 2006, Mantua *et al*. 2010, Poff *et al.* 2010, Barnett 2008, Kim *et al.* 2002).

The situation in South-Central California may be more complex, and difficult to model, because of the uncertainty surrounding the projected climate changes; further the response of South-Central California Coast steelhead to these climate driven changes is uncertain (Boughton 2010a, Boughton *et al.* 2006, 2007b).

Fig.5-2 Seasonal Coastal Upwelling Pattern Along the California Coast (Courtesy NOAA)

3. The timing and strength of the spring upwelling transition and its effect on production and recruitment of marine populations

Coastal upwelling of cold water carries significant plankton and krill populations into coastal waters. These populations are an important food source for young Pacific anadromous salmonids entering the ocean to begin the marine phase of their life cycle. At present there is some evidence that coastal upwelling has become stronger over the past several decades due to greater contrasts between warming of the land (resulting in lower atmospheric pressure over the continent) relative to ocean warming (Bakun 1990). Regional climate models project that not only will upwelling-favorable winds be stronger in summer, but that the peak in seasonal upwelling will occur later in the summer (Snyder *et al.* 2003), delaying the availability of an important food source to juvenile Pacific anadromous salmonids. However, the winds may not be able to mix this light buoyant water or transport it offshore, resulting in the inability of cold nutrient-rich water to be brought to the sea surface. Thus, phytoplankton blooms may not be as intense, which may impact organisms up the food chain including Pacific anadromous salmonids (Roemmich and McGowan, 1995). Given that the future climate will be warmer, the upper ocean at the watershed scale will likely be, on average, more stratified. The result will be lower primary productivity everywhere (with the possible exception of the nearshore coastal upwelling zones).

4. Ocean warming, increased stratification and their effect on pelagic habitat

The vertical gradient in ocean temperature off California has intensified over the past several decades (Palacios *et al*. 2004). Areas with enhanced riverine input into the coastal ocean will also see greater vertical stratification. Generally warmer ocean conditions will cause a northward shift in the distribution of most marine species, and possibly the creation of reproductive populations in new regions. Existing faunal boundaries are likely to remain as strong boundaries, but their resiliency to shifts in ocean conditions due to global climate change is not known. The effects of any shift of pelagic species, particularly predator and prey species, on Pacific anadromous salmonids are unclear, but may vary with

individual species such as steelhead (Lindley *et al.* 2007).

5. Changes in gyre strength, regional transport, and source waters to the California Current and their impact on species distribution and community structure

Observations of the biota of the California Current show that there are pronounced latitudinal differences in the species composition of plankton, fish, and benthic communities, ranging from cold water boreal sub-arctic species in the north to warm water subtropical species in the south.

Copepod biodiversity increases in coastal waters due to shoreward movement of offshore waters onto the continental shelf, which is caused by either weakening of southward wind stress in summer or strengthening of northward wind stress in winter.

Regardless of the season, the source waters that feed into the California Current from the north and from offshore can exert some control over the phytoplankton and zooplankton species that dominate the current. The occurrence of low returns of Pacific anadromous salmonids when the Pacific Decadal Oscillation (PDO) is in a positive, warm-water phase, and high returns when the PDO is in a negative, cold-water phase suggests a mechanistic link between PDO sign change and the growth and survival of Pacific anadromous salmonids. However, for Alaska salmon, the typical positive PDO condition is associated with enhanced streamflows and nearshore ocean mixed-layer conditions favorable to high productivity (Mantua and Hare 2002,

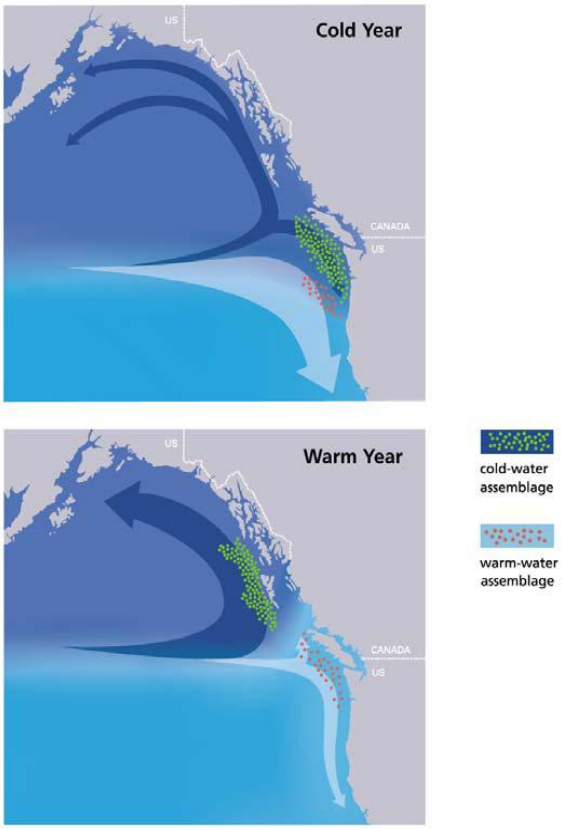


Fig. 5-3. Shift in Cold and Warm-Water Faunal Assembles During Pacific Decadal Oscillations and El Niño/La Niña/Southern Oscillations (Osgood 2008)

Mantua *et al*. 1997). Most climate models project roughly the same timing and frequency of decadal variability in the North Pacific under the impacts of global warming. However, combined with a global warming trend, the CCE is likely to experience more years of positive, warm phases (*i.e.,* periods of lower productivity).

Two other marine related effects of global climate change are relevant to steelhead as well as other Pacific anadromous salmonids: sea-level rise and ocean acidification.

Sea Level Rise. One of the several life history strategies exhibited by steelhead is the "lagoon-anadromous" strategy in which

juveniles rear a portion of the year in the estuary of their natal river or stream. Studies in small coastal estuaries seasonally closed off from the ocean by sand bars have shown these areas to be productive rearing areas for *O. mykiss*, with juveniles growing fast enough to migrate to the ocean after their first year, and generally at a larger size than juveniles rearing in the freshwater portion of the stream system. Fish that enter the ocean at a larger size exhibit greater survival rates in the ocean, and thus tend to be disproportionately represented in the adult spawning population (Hayes *et al.* 2008, Bond 2006).

Changes in sea level, which have the potential to affect important estuarine habitats, have already been reported and are expected to continue. Researchers have projected that by 2035-2064 global sea level rise will range between 6-32 cm above 1990 levels, regardless of the emission scenarios used. However, between 2070-2100 the projected range of sea level rise varies between 11-54 cm to 17-72 cm depending on the emission scenario used (Cayan *et al*. 2009, 2008b, Pilkey and Young 2009, Raper and Braithwaite, 2006). This more recent analysis suggests a larger rise in sea level than previously projected by Hayhoe *et al*. (2004, Ewing 1989). A projected 1m rise in sea level would lead to the potential inundation of 65 percent of the coastal marshlands and estuaries in the continental United States. In addition to the inundation and displacement of estuaries/lagoons, there would be shifts in the quality of the habitats in affected coastal regions. Prior to being inundated, coastal watersheds would become saline due to saltwater intrusion into the surface and groundwater (Pilkey and Young 2009). A rise in sea level will most dramatically affect those estuaries which have been confined by surrounding development that prohibits their boundaries from naturally shifting in response to inundation. As discussed in Chapter 4 (Current DPS-Level Threats Assessment), estuarine habitat functions and habitat loss may be of particular importance to steelhead, though their role in South-Central California has been the subject of limited investigation.

Ocean Acidification. Another projected effect of climate change on the marine environment is acidification. As a result of increased anthropogenic CO_2 in the oceans since the industrial revolution, the pH of seawater has dropped from 8.2 to 8.1 (on a logarithmic scale, this represents a c. 26% increase in the concentration of H^+ ions). Estimated future increase in atmospheric CO_2 could result in a decrease in surface water pH of 0.3-0.4 by the end of the century, depending on the emission scenario used (Feely *et al.* 2008, Feely, *et al*. 2004). The effects of CO_2 concentration in the marine environment are not uniform, but are expected to vary with water depth, circulation and temperature, and in coastal waters with upwelling and freshwater input and nutrients (National Research Council 2010).

The reaction of CO_2 with seawater reduces the formation of calcium carbonate used in skeleton and shell formation of marine organisms, and can change many biologically important chemical reactions. The effects of ocean acidification will vary among organisms. As an example, ocean acidification has been shown to reduce the abundance of some carbonate forms, such as pteropods (Fabry *et al.* 2008). Because

pteropods are an important food source for certain species of Pacific salmon (*e.g.*, sockeye, pink, and chum salmon), a reduction in pteropods can affect the marine growth of these species. One bioenergetics/food web model predicts that a 10% reduction in pteropod production would result in a 20% reduction in the growth of pink salmon (Aydin *et al.* 2005). Because of the lack of information on the marine phase of steelhead, it is unclear if pteropods or other carbonate forming prey constitute a signification portion of the diet of steelhead when in the marine environment. The significance of ocean acidification for steelhead and other anadromous salmonids may depend on the change of pH and carbonate equilibrium, its effect on pteropods and pelagic planktonic community structure, and the ability of juvenile and adults to modify their diets accordingly (Schwing *et al*. 2010). The long-term consequences of ocean acidification on marine ecosystems are poorly understood, but potentially significant (National Research Council, 2010). Because the marine life history phase of steelhead is not well understood, as noted above, the long-term consequences of ocean acidification for this species are even less certain (Nielsen and Ruggerone 2009, Meyers *et al*.1996).

5.2 CLIMATE INFLUENCES ON STEELHEAD

5.2.1 Steelhead Life Histories and Habitats

The intricate life history of salmonids as well as the complexity of their multiple aquatic habitats means that it is rare that an isolated environmental factor, or driver, is responsible for variability in a given population. Numerous climate stressors (*e.g.*, warming, sea level rise, freshwater flow) affect population productivity and structure throughout the habitats and life history stages of a species. To understand the implications of climate change for salmonids, it is useful to establish a conceptual framework that organizes this complexity (Schwing *et al.* 2010). Such a framework is reflected in the viability criteria and recovery strategy described in Chapters 6, Steelhead Recovery Goals, Objectives, & Criteria and 7, Steelhead Recovery Strategy, in this Recovery Plan which is based on the current climate conditions, and should provide guidance in the adaptive management of steelhead as the climate changes in the SCCS Recovery Planning Area.

The framework used here organizes complexity into four broad spheres: 1) the multiple life history pathways that are open to salmonids as a function of their adaptations and ecological tolerances; 2) the environmental opportunities that aquatic habitats offer to salmonids at each stage of their life history (Mobrand *et al*. 1997); 3) the suite of habitat-generating processes and stressor-pathways, by which climate (and other drivers) create, destroy, or maintain these aquatic habitats; and 4) the spatial connectivity and timing by which the other domains are knitted into a productive and viable salmonid population. This way of organizing the material allows a systematic treatment of each life stage, each habitat used by each life stage, and each way in which climate change potentially impacts each habitat-generating mechanism (Waples *et al.* 2010, 2008a, 2008b, Schindler *et al*. 2008).

5.2.2 Life History Pathways

The life history network described in Chapter 2, Sub-section 2.6 (South-Central California Coast steelhead Freshwater Life Cycle Habitat Use) can be related to the Viable Salmonid Population (VSP) concept of McElhany *et al*. (2000), where viability is measured in terms of four parameters: abundance, productivity, diversity, and spatial structure. Each link in a habitat network involves an interaction between a life history stage and a particular habitat, and has two attributes that emerge from this interaction: survival and capacity. The patterns of survival and capacity across the network translate to abundance and productivity, respectively, for the population as a whole, two of the four VSP parameters (Mobrand *et al*. 1997).

Diversity and spatial structure, the other two VSP parameters, emerge from the parallel linkages in the life history network. Diversity has two broad components: the diversity of pathways offered by the environment (habitat diversity), and the ability of the species to pursue those opportunities (phenotypic plasticity, generalist strategies, and genetic diversity). Spatial structure, the fourth VSP parameter, provides the physical space for parallel linkages to occur in greater numbers and larger capacities, thus increasing the overall resilience of the population.

Because climate is changing, it can be expected that steelhead populations will respond, along with other species, but in variable ways. In so far as evolution has raised steelhead populations to an adaptive peak, climate change will generally be expected to reduce the fitness of steelhead populations at least temporarily (Schwing *et al*. 2010).

The interactions between steelhead at distinctive phases in their life history and the habitat conditions characteristically associated with those life history phases should be the focus of future research into the effects of projected climate change on steelhead life histories and habitats.

5.2.3 Environmental Opportunities and Habitat Diversity

Environmental opportunities are times and places where physical, chemical and biological conditions support the survival, growth, migration and reproduction of anadromous salmonids. Some of these conditions are predictable or discernible, and some are not. Frequently the relatively predictable components are physical or possibly chemical conditions, traceable to the interaction of climate acting on a geologic template (Buffington *et al*. 2004). In freshwater habitats, these physical components of environmental opportunity are generally functions of variation along three axes: flow, channel morphology or substrate, and water quality - especially temperature (Beechie *et al*. 2010, Orr *et al*. 2008, Newson and Large 2006, Thorp *et al*. 2006, Stanford *et al*. 1996). In marine habitats, climate-related opportunities tend to be physically structured by water temperature, currents and circulation patterns, chemistry (especially acidification), and for the near-shore domain, sea level rise.

Climate largely shapes where in time and space anadromous salmonids can persist or flourish, within the constraints of past evolution and the geologic/topographic

template. A change in climate means a change in the space and time where anadromous salmonids can persist and flourish; but these changes are filtered through a set of processes in the watershed, by which precipitation, elevated CO_2, and air-temperature patterns are converted into flow, and stream temperature patterns (Schwing *et al.* 2010).

5.2.4 Habitat-Forming Processes

The processes that convert climate patterns into spatial and temporal habitat for salmonids are sometimes called habitat-forming processes (Beechie and Bolton 1999). Salmonid habitats are generated by the operation of four broad process domains: watershed (or terrestrial), fluvial, estuarine, and marine domains (Montgomery 1999).

These functional domains can be further subdivided to make meaningful connections between climate processes, spatial and temporal habitat, and salmonid life history pathways. For example, the precipitation pulses from Pacific storm systems drive fluvial processes that tend to produce an ordered sequence of channel types from headwaters to the estuary (Montgomery and Buffington 1997). Some of these, such as step-pools and pool-riffle channels, play specific roles (rearing and spawning, respectively) in salmonid life history.

These broad processes can also be subdivided to indicate differential response to climate change. (Boughton *et al.* 2009, Davy and Lapointe 2007, Buffington *et al*. 2004, Moir *et al*. 2004, Kahler *et al*. 2001). For example, the fluvial domain can be divided into a sediment-transport domain and a response, or alluvial, domain downstream (Montgomery and MacDonald 2002). These are expected to have different sensitivities to changes in flow regime and sediment supply. Estuarine domains tend to be small interfaces between the much more extensive fluvial and marine domains; they thus exhibit a dynamism that is inherently responsive to alteration of either marine or fluvial dynamics (Jay *et al*. 2000).

As with the life history networks of anadromous salmonids, if multiple ecosystem processes produce the same sort of resource for a salmonid population, resiliency of the population tends to improve. Parallel linkages fall into two general categories: redundant pathways and alternative pathways (Edelman and Gally 2001, Tononi *et al*. 1999).

Redundant pathways are multiple instances of the same process providing the same outcome. For example, if headwater streams provide fish with thermal refugia during the summer, a stream system with multiple tributaries, each providing a refugium, is highly redundant. Redundancy provides resilience against small-scale disturbances, such as chemical spills (Nielsen *et al*. 2000) or wildfire. But redundant pathways tend to respond in a coordinated fashion to large-scale disturbances, such as droughts or heat waves, and thus provide little resilience to them because they would all tend to respond the same way.

Alternative pathways are different processes that produce the same physical conditions. For example, thermal refugia can be generated either by a headwater stream (via the temperature lapse rate), or

by a coastal lagoon (via proximity to the ocean heat sink). Due to the large thermal mass of the ocean, coastal thermal refugia would probably be relatively resilient to heat waves, and may even be enhanced by them through onshore movement of fog. Alternative pathways are less likely than redundant pathways to exhibit a consistent response to a large-scale disturbances, and this can promote resiliency even more effectively than redundancy (Levin and Lubchenco 2008). Moreover, alternative pathways appear able to make living systems both more robust and more resilient to sustained directional change – such as climate change - not just disturbances (Whitacre and Bender 2010, Moritz et al. 2005, Carlson and Doyle 2002, Tononi *et al*. 1999).

5.2.5 Spatial Connectivity and Timing

The fourth element in this conceptual framework deals with the continuity of environmental opportunities for successive life stages of anadromous salmonids. The timing of fish movement from one habitat to another depends on whether environmental conditions in the habitats and migration corridors connecting them are suitable, and whether fish are at a suitable stage of development to require or be capable of the movement between habitats.

Rapidly changing climate may alter such opportunities by creating critical mismatches in development and habitat conditions to which anadromous runs are currently adapted. In principle, a river-ocean system could contain the full suite of habitats necessary for all life stages, but if the fish cannot reliably move from one habitat type to the next at the appropriate time in its life cycle, the system is unlikely to support a viable population.

Adult South-Central California Coast steelhead currently enter freshwater in the winter and late spring when flows are high and migrate to high elevation habitats that will be inaccessible to later in the season when flows are lower. The timing of these flows depends on precipitation. Following successful spawning and incubation fry emerge some time later, depending almost entirely on water temperature experienced while they are in the gravel. Growth and development to the smolt stage also depends upon temperature. Smolts typically enter the ocean from late winter to late spring, when feeding conditions are optimal due to seasonal upwelling supporting enhanced primary production. The timing of salmon life cycle stages has been shaped by centuries or millennia of climate conditions, and can be adversely affected by rapid climate change that alters the timing, rate, and spatial location of key physical and biological processes (Crozier *et al*. 2008).

5.3 RECOVERY PLANNING FOR SOUTH-CENTRAL COAST CALIFORNIA CLIMATE CHANGE

5.3.1 Core Principles

While some physical parameters of climate change are likely to be predictable, the response of ecosystems and hence the future conditions of steelhead habitats are much less predictable. This suggests that the over-arching strategy for dealing with climate changes will be to enhance the resilience of the steelhead metapopulations to respond to ecosystem changes, through

forecasting and managing the physical envelope of the species according to a few core principles (see Boughton *et al.* 2010a for a discussion of these principles):

- Widen opportunities for fish to be opportunistic (*i.e.,* exploit a variety of habitat types)
- Maximize connectivity of habitats (i.e., within and between habitats)
- Promote the evolvability of populations and metapopulations (*i.e.,* the ability of a population to generate novel functions, through genetic change and natural selection, that help individuals of a population survive and reproduce)
- Maintain the capacity to detect and respond sustainably to ecosystem changes as they occur.

The viability criteria outlined in Chapter 6, Steelhead Recovery Goals, Objectives & Criteria, and the recovery strategy identified in Chapter 7, Steelhead Recovery Strategy, applied these core principles to the current climate regime, and should be applied to future climate regimes.

As a result, there will likely be a need to extend the results of the TRT. The following climate change related questions have already been identified by the TRT:

How will the climate trends alter the wildfire regime, and thus alter sedimentalogical and hydrological processes that affect the distribution of steelhead habitat?

Will different watersheds develop distinctly different wildfire regimes, with implications for habitat dynamics, carrying capacity, and viability?

What environmental factors maintain suitable creek temperatures during the summer, and will they moderate the response of stream temperatures to climate change?

Are there natural freshwater refugia that sustain *O. mykiss* during droughts longer than the generation time of the fish?

How are patterns of intermittency likely to respond to climate change, and where are suitable flows likely to intersect with suitable water temperatures under scenarios of climate change?

6. Steelhead Recovery Goals, Objectives & Criteria

"Recovery is the process by which listed species and their ecosystems are restored and their future safeguarded to the point that protections under the ESA are no longer needed. A variety of actions may be necessary to achieve the goal of recovery, such as the ecological restoration of habitat or implementation of conservation measures with stakeholders."

Endangered and Threatened Species Recovery Planning Guidance, National Marine Fisheries Service, 2010

6.1 DPS RECOVERY GOAL

The goal of this Recovery Plan *to prevent the extinction of South-Central California Coast steelhead in the wild and ensure the long-term persistence of viable, self-sustaining, wild populations of steelhead distributed across the South-Central California Coast Steelhead (SCCCS) Distinct Population Segment (DPS). It is also the goal of this Recovery Plan to re-establish a sustainable South-Central California Coast steelhead sport fishery.*

Recovery of the SCCCS DPS will require the protection, restoration, and maintenance of habitats of sufficient quantity, quality, and natural complexity throughout the SCCCS Recovery Planning Area so that the full range of all life history forms of *O. mykiss* (*e.g.*, switching between resident and anadromous forms, timing and frequency of anadromous runs, and dispersal rates between watersheds) are able to successfully use a wide variety of habitats in order to overcome the natural challenges of a highly variable physical and biological environment.

A **viable population** is defined as a population having a negligible risk (< 5%) of extinction due to threats from demographic variation, non-catastrophic environmental variation, and genetic diversity changes over a 100-year time frame. A **viable DPS** is comprised of a sufficient number of viable populations broadly distributed throughout the DPS but sufficiently well-connected through ocean and freshwater dispersal to maintain long-term (1,000-year) persistence and evolutionary potential (McElhany *et al*. 2000).

6.2 DPS RECOVERY OBJECTIVES

To ensure recovery of the SCCCS DPS, specific objectives are necessary to guide recovery efforts and to measure the species' progress towards recovery. Similarly, specific, measurable and objective criteria are also necessary to describe the recovery of the species.

Steelhead in South-Central California occupy a wide array of watersheds, some portions of which are severely degraded with highly modified natural watershed processes and streamflows. Under these degraded habitat conditions, steelhead populations in some watersheds have declined to very low numbers

where they continue to persist. In other watersheds, populations have been extirpated, particularly near the southern end of the species' range. Existing threats constrain the species' current distribution to small, disjunct portions of its historic range and preclude it from expressing its full range of life history strategies in response to naturally varying habitat conditions. In order to recover, the species needs substantially higher numbers of returning adults, successful spawning and rearing in freshwater and estuarine environments, and successful emigration of juveniles to the ocean. To achieve these goals, it is essential to preserve and restore the species' existing habitat, as well as restore its access to historically important spawning and rearing habitats throughout the SCCCS Steelhead Recovery Planning Area. Individual watersheds, and in some cases groups of watersheds, must have the capacity to support self-sustaining populations of steelhead in the face of natural variation in environmental conditions such as droughts, floods, wildfires, variable ocean-rearing conditions, and long-term climate changes.

To recover steelhead, the following objectives have been identified:

- Prevent steelhead extinction by protecting existing populations and their habitats
- Maintain current distribution of steelhead and restore distribution to some previously occupied areas
- Increase abundance of steelhead to viable population levels, including the expression of all life history forms and strategies
- Conserve existing genetic diversity and provide opportunities for interchange of genetic material between and within viable populations
- Maintain and restore suitable habitat conditions and characteristics to support all life history stages of viable populations
- Conduct research and monitoring necessary to refine and demonstrate attainment of recovery criteria

6.3 RECOVERY CRITERIA

Prior to determining that a species has "recovered" and can therefore be removed from the List of Threatened and Endangered Species (*i.e.,* delisting) or have its protective status lowered from "endangered" to "threatened" (*i.e.,* down listing), certain criteria for recovery, related to the condition of the species and the status of the threats to the species, must be met. In the case of delisting the SCCCS DPS, biological recovery criteria regarding the abundance, productivity, spatial structure, and diversity of the populations within the DPS and the DPS as a whole, are the measures of recovery. Threats abatement criteria are indicators that key threats to the populations and DPS have been abated or controlled. Both types of recovery criteria will be used by NMFS to assess whether the species is recovering (moving towards meeting the criteria, and down listing may be appropriate) or has recovered (meets the criteria and delisting may be appropriate). Several of the criteria have not been established quantitatively because additional research is needed to define or refine them. For this reason, one of the six recovery objectives focuses on the research and monitoring needed to refine the criteria and directly measure whether steelhead populations are meeting the criteria. Given the species' condition and the severity of the threats to the species, however, it is clear that significant increases in population and DPS health and reductions in critical threat sources are needed.

The Technical Recovery Team (TRT) identified two different approaches to articulating viability criteria: 1) prescriptive criteria, which identify

specific targets, generally expressed in quantitative terms, and 2) performance criteria, which identify standards for final performance, expressed in theoretical terms. In light of uncertainties regarding South-Central California Coast steelhead, 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*. 2007b, 2006). Because of the uncertainty of the efficacy of the provisional prescriptive criteria, which are based on limited quantitative population data from South-Central California Coast steelhead, the Recovery Plan uses the performance based criteria until more specific prescriptive criteria are available.

6.3.1 Biological Recovery Criteria

The TRT developed general viability criteria for both individual steelhead populations and for the SCCCS DPS as a whole. These criteria describe characteristics of both individual populations and the DPS that if achieved would indicate that the DPS is viable, and therefore at a low risk of extinction over a specific period of time. [1] The population and DPS criteria are independent of anthropogenic effects in the sense that they must be met regardless of habitat conditions and human-caused threats. The time frame and related recommended criteria address the preservation of the evolutionary potential of the species (*i.e.*, existing genetic, phenotypic, and behavioral diversity) by ensuring that the DPS will persist over a long enough period of time to exhibit future evolutionary changes such as adaptation or diversification in response to environmental changes. Preserving the evolutionary potential of the species is an important component in ensuring the species' long-term viability.

The viability criteria recommended by the TRT provide guidance for judging recovery of steelhead populations and the SCCCS DPS given the current level of knowledge and understanding of the biology and ecology of South-Central California Coast steelhead. All of the recommended criteria carry varying levels of uncertainty depending on the amount of information available on steelhead in the SCCCS Recovery Planning Area. Given the high levels of scientific uncertainty, NMFS proposes to adopt many of the viability criteria as recovery criteria until such time as sufficient scientific information is available to refine the criteria for assessing population and DPS viability; additionally, these criteria will be reviewed when NMFS conducts 5-year status reviews.

[1] For a detailed discussion of the methods used by the TRT to develop the recommended viability criteria, see Boughton *et al*. 2007b.

Table 6-1. Biological Recovery Criteria for the South-Central California Coast Steelhead DPS.

POPULATION-LEVEL CRITERIA – Apply to Populations selected to meet DPS-level criterion D.1.1		
Criterion Type[1]	**Recovery Threshold**	**Notes**
P.1 Mean Annual Run Size	Run size is sufficient to result in an extinction risk of <5% within 100 yrs.	Monitoring run size will provide information on year-to-year fluctuations in the population necessary to determining the appropriate recovery threshold for individual populations. Research on the role of non-anadromous spawning fraction in stabilizing anadromous faction will also enable refinement of the minimum recovery threshold (see Boughton *et al.* [2007b] for discussion of steps in determination of threshold value for each viable population).
P.2 Ocean Conditions	Run Size criterion met during poor ocean conditions	"Poor ocean conditions" determined empirically, or size criterion met for at least 6 decades
P.3 Spawner Density	*Unknown at present*	Research needed
P.4 Anadromous Fraction[2]	N = 100% of Mean Annual Run Size	Requires further research (see note above)
DPS-LEVEL CRITERIA		
Criterion Type	**Recovery Threshold**	
D.1 Biogeographic Diversity	1. Biogeographic Population Group contains minimum number of viable populations: Interior Coast Range (4 populations); Carmel River Basin (1 population); Big Sur Coast (3 populations); San Luis Obispo Terrace (5 populations) (see Boughton *et al.* 2007b for detailed discussion) 2. Viable populations inhabit watersheds with drought refugia 3. Viable populations separated from one another by at least 68 km or as widely dispersed as possible[3]	
D.2 Life-History Diversity	All three life-history types (fluvial-anadromous, lagoon-anadromous, freshwater resident) be exhibited and distributed across each Biogeographic Population Group.	

[1] It is assumed that all spawner criteria represent escapement (*i.e.*, unharvested spawning adults) rather than migrating adults that may be captured before having an opportunity spawn.
[2] The anadromous fraction is the percentage of the run size that must exhibit an anadromous life history to be counted toward meeting the mean annual run size criteria. However, the recovery strategy recognizes the potential role of the non-anadromous form of *O. mykiss* and includes recovery actions which would restore habitat occupied by the non-anadromous form, as well as reconnect such habitat with anadromous waters, and thus allow the anadromous and non-anadromous forms to interbreed, and the non- anadromous forms to potentially express an anadromous life history.
[3] This geographic separation is based on the maximum width of recorded historic wildfires; see additional discussion below under Section 6.3.1. 2

The population level criteria apply to certain populations in all of the BPGs.[2] Further research

is needed to refine the population criteria in the BPGs; for example, data on the magnitude of natural population fluctuations could reveal that smaller mean run sizes would be sufficient to attain viability in some basins (Williams *et al.* 2011). Additionally, further research could refine the role of each of the BPGs in the recovery of the SCCCS DPS. At a minimum, all BPGs will need to achieve sufficient spatial structure and diversity (*i.e.,* two of the four criteria that define a viable DPS in the wild). Dispersal of steelhead between BPGs may be an important mechanism for maintaining viability of steelhead populations. In addition, preservation of the resident form of the species and habitats that support that life history form may be critical to conserving the genetic diversity of steelhead and providing stock that can re-establish and support the fluvial-anadromous and lagoon-anadromous life history strategies.

6.3.1.1 Discussion of Population-Level Recovery Criteria

Criterion P.1 – Mean Annual Run Size. There is substantial uncertainty regarding the mean annual run size that would represent viable anadromous *O. mykiss* populations throughout the SCCCS DPS. The TRT estimated a mean annual run size for the DPS using a method derived from Lindley's 2003 "random-walk-with-drift" model and quantitative field data for one anadromous *O. mykiss* population and 19 Chinook salmon populations in California's Central Valley for estimating variability in population growth estimates (Lindley 2007, 2003). The resulting criterion of 4,150 spawners per year provides for a 95 percent chance of persistence of the population over 100 years and applies to a generalized situation where there are no quantitative field data on specific local populations (Boughton *et al*. 2007b). Based on the irregular inter-annual patterns of precipitation, anecdotal accounts of highly variable spawning runs and the expectation that larger abundances buffer populations against the increased extinction risks that come with variations in freshwater and marine survival, it can be expected that an average of 4,150 spawners per year, persisting through a cycle of poor ocean conditions would be adequate to safeguard a population (see also discussion below, P.2 – Ocean Conditions). This target may be biologically feasible in larger watersheds within the SCCCS Recovery Planning Area, such as occur within the Interior Coast Range and Carmel River Basin BPGs), but may be too high for relatively small watersheds that may support viable populations at average run sizes well below 4,150 (Boughton *et al.* 2007b). Factors such as reliable access to spawning and rearing areas, a stable freshwater environment, the role of non-anadromous forms of *O. mykiss*, inter-watershed exchanges of anadromous forms of *O. mykiss*, or other factors, may play an important role in refining the population-level recovery criteria. Additionally, data on the magnitude of natural fluctuations in anadromous run sizes in individual watersheds may identify a smaller mean run size that is sufficient for viability in some basins (Williams *et al.* 2011).

The separate watersheds comprising each BPG are treated as individual steelhead populations for the purposes of meeting the run-size criterion. Because of uncertainty regarding the applicability of 4,150 spawners per year to many of the watersheds within the SCCCS Recovery Planning Area and the lack of current data to develop more refined criteria, this Recovery Plan proposes that performance-based run-size criteria be developed for different core populations throughout the DPS. Development of this criterion for each population would utilize a precautionary approach towards determining run sizes that provide for a 95 percent chance of persistence of the population over 100 years. In general, the 4,150 number can be thought of as an approximate upper bound

[2] See Chapter 2 and Table 2-2, Steelhead Biology and Ecology and Chapter 7, Recovery Strategy, for a discussion of these populations.

on what the ultimate viability targets will turn out to be, although there is a chance that development of a performance-based criterion would result in values higher than 4,150 spawners in some watersheds (Boughton *et al*. 2007b). This criterion will be reviewed during NMFSs periodic 5-year review of the Recovery Plan, and potentially during the Southwest Fisheries Science Center's 5-year status review updates for Pacific salmon and steelhead listed under the ESA.

Methods exist for estimating extinction risk through the use of time-series of spawner counts (Dennis *et al*. 2006, Lindley 2007, 2003, Holmes 2001). In general, about 20 years of data are necessary to obtain reasonable confidence in such estimates (Lindley 2007, 2003), though recovery to some level is necessary in some watersheds to have a sufficient number of spawners to refine viability criteria. The development of performance-based criteria requires an understanding of some key risk factors before settling on final viability targets, including: 1) the magnitude of year-to-year fluctuations in spawner abundance; 2) the magnitude and duration of poor ocean survival during poor ocean conditions; and 3) the ability or inability of rainbow trout to contribute progeny to steelhead populations and thereby bolster steelhead populations during periods of otherwise poor survival. These factors and the years of data collection required, highlight the critical need for immediate implementation of population abundance monitoring in key watersheds. However, some populations may currently have run sizes so low that obtaining accurate counts would be difficult because of the small sample size, or surveying may be detrimental because of the associated mortality associated with sampling techniques. Collecting useful data may not be practical until such populations have been recovered to some level, depending on the field methods used for monitoring. Boughton *et al.* (2007b) describe a decision tree for use in refining and establishing a viability criterion for mean population size.

Criterion P.2 – Ocean Conditions. Year-to-year variation in a population's survival and/or reproduction can cause large fluctuations in population growth rate irrespective of population size. Consequently, larger variance causes the number of fish to fluctuate more, increasing the chance of the population fluctuating to zero. A large mean population growth rate lowers this risk by shortening the recovery time from downward fluctuations, and a large mean population size keeps the population further away from zero to begin with (McElhany *et al*. 2000, Lande 1993, Foley 1997, 1994).

Variation in ocean conditions is known to have dramatic impacts on marine survival of Pacific salmonids (Mantua and Hare 2002, Mueter *et al.* 2002, Mantua, *et al.* 1997). A conservative working assumption is that salmonid ocean survival fluctuates widely and is connected with variations in ocean conditions. Periods of poor ocean conditions (as reflected in a significant increase in mean ocean mortality of *O. mykiss*) can last for multiple decades and may result in as much as a five-fold decrease in ocean survival of salmonids (Mantua *et al.* 1997). A population that meets the run-size criterion (P.1) during a period of good ocean survival is likely to decline to risky levels when ocean survival deteriorates for long periods. Therefore, a simple but effective criterion for ocean condition is that the run size criterion must be met during a period of poor ocean survival. This criterion could be met via two distinct strategies:

1. Monitor population size for at least the duration of the longest-period climate "cycle" (about 60 years according to Mantua and Hare [2002], though others question the notion of predictable cycles), or
2. Concurrently monitor population size and ocean survival, so that periods of low ocean survival can be empirically determined.

Data on ocean survival (derived from smolt counts combined with adult counts) should be useful for separating the effects of ocean cycles and watershed conditions on population growth. Investment in both smolt counts and adult counts allows an estimation of ocean survival as distinct from freshwater production and survival (with only adult counts, the vital rates in the two habitats are confounded and cannot be estimated separately). In addition, short-term improvements in run size due to watershed restoration could be distinguished from short-term improvement due to ocean cycles. The Coastal Monitoring Plan being prepared by NMFS and CDFG (Adams *et al.* 2011) provides for a series of "Life Cycle Monitoring Stations" which involve the monitoring of smolts and spawners to allow ocean survival to be estimated for specific watersheds; if fish from other watersheds have similar rates of ocean survival, these results could be extrapolated to address this issue for South-Central California Coast steelhead.

As performance-based run-size criteria are developed for populations within the SCCCS DPS, the methods and data used to develop those values may change the ocean conditions criterion or even preclude the need for such a specific criterion, though not the consideration of marine conditions. As discussed above, the magnitude and duration of poor ocean survival on the extinction risk of the population is a key factor to consider when developing the run-size criterion.

Criterion P.3 – Spawner Density. The distribution of adult or juvenile fish across a watershed can influence the viability of a population. If too thinly distributed, populations can decline as a result of the difficulty in locating mates, but may also reduce their vulnerability to localized catastrophes or environmental variations by occupying a broader range of habitats. If too densely packed within a limited spatial distribution, populations may be more vulnerable to unpredictable environmental events as all the members of the population experience the same conditions. The TRT concluded that a viability criterion related to the density of spawners (at some scale) in a population is warranted, particularly for populations that were historically large, but are unlikely to be recovered to those historic levels due to a risk that a thinly distributed population in such a watershed could meet the criterion for mean size, and yet not be viable. The TRT also found that the viability threshold should be high enough to ensure that fish generally inhabit good-quality habitats that promote the resilience of the population.

A potentially suitable threshold for both these purposes is the density at which intra-specific competition for redd sites becomes observable. For coho salmon (*O. kisutch*) this appears to be on average about 40 spawners per kilometer (one spawning pair per 50 meters of stream length), although individual streams vary considerably around this mean (Bradford *et al*. 2000). However, the TRT could not find data for deriving a corresponding steelhead criterion. The Coastal Monitoring Plan proposes to implement redd-counting for monitoring salmon and steelhead in the northern coastal area of California (Aptos Creek to the Oregon border). This should provide data that will be useful for deriving a specific spawner density criterion; also redd-counts could be made in the SCCCS Recovery Planning Area if it is necessary for developing specific South-Central California criterion, or as means of estimating the anadromous run-size in individual watersheds.

Criterion P.4 – Anadromous Fraction. Anadromous fraction is the mean fraction of reproductive adults that are anadromous (steelhead). Steelhead in the SCCCS Recovery Planning Area co-occur with rainbow trout. Elsewhere, steelhead have been observed to have trout among their progeny, and vice versa (Zimmerman and Reeves 2000). It is not known how often these transitions occur in South-

Central California Coast *O. mykiss*, or what factors bring them about, though clearly individual populations can have more than one life history type (Sogard *et al*. 2012, Hendry *et al.* 2004, 2004a). 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.

Interchange between resident and anadromous fish groups would almost certainly lower the extinction risk of both groups, for the same two reasons that dispersal between separate steelhead populations reduces risk: 1) the existence of a "rescue effect" and 2) the possibility of recolonization (Hanski and Gilpin 1997, Foley 1997). The rescue effect would occur at low steelhead abundance, when input from the trout population prevents their complete disappearance. Recolonization occurs when steelhead disappear completely, but are regenerated by the trout population via "recolonization" of the steelhead niche (Hendry *et al.* 2004). These phenomena may have maintained steelhead in the Carmel River system, and possibly Salmon Creek and other South-Central California Coast watersheds, in recent times, since most contemporary steelhead runs appear far too small to be self-sustaining (Boughton *et al*. 2005). Unfortunately, lack of data on life history polymorphism prevents a reasonable estimate for the magnitude of the rescue effect, or for a viability threshold for anadromous fraction. Lacking such data, the precautionary criterion for anadromous fraction must assume that the rescue effect is negligible, and that anadromous fraction must be 100% - that is, when applying the population size criterion discussed previously, 100% of the spawners must be annual anadromous immigrants. Future research on this topic could be used to estimate a viability threshold that is more efficient than the precautionary "100% rule." One of the most useful scientific tools for addressing the interchange question involves otolith microchemistry but, as this technique requires lethal sampling of fish, a scientific collecting permit under section 10(1)(A) of the ESA would be required to authorize mortality using this methodology. Newer, non-lethal genetic techniques are also being explored (D. Pearse, personal communication). However, in populations where anadromous fish are currently quite rare, it will probably be necessary to recover run sizes somewhat before numbers are sufficient for useful ecological research.

6.3.1.2 DPS-Level Recovery Criteria

Criterion D.1 (.1, .2, and .3) – Biogeographic Diversity. This criterion contains three elements that address issues of redundancy and separation between populations and within-watershed conditions to provide for resilience against natural environmental events such as droughts and wildfires. The BPGs are an important component in the recovery of the SCCCS DPS and all BPGs must be restored to viability before the DPS as a whole can be recovered and eventually delisted. The delineation of BPGs was based on suites of basic environmental conditions (*e.g.,* large inland and short coastal stream networks in a range of climatic, terrestrial, and aquatic regimes). The recovery of multiple watersheds and populations in each BPG ensures that there are sufficient populations within the BPG and across the DPS to provide resiliency in the face of environmental fluctuations, and also that a variety of habitat types and conditions are represented (*e.g.,* different stream gradients and estuary size, complexity and function).

Recovery of the SCCCS DPS will require recovery of a sufficient number of viable populations (or sets of interacting trans-watershed populations) within each of the four BPGs to conserve the natural diversity (genetic, phenotypic, and behavioral), spatial distribution, and resiliency of the DPS as a whole.

Criterion D.2 – Life History Diversity. Essential to the recovery and long-term conservation of the SCCCS DPS is the preservation and restoration of all the life history forms and strategies the species has evolved to exploit the diversity and range of habitat conditions that are characteristic of South-Central California. These life history forms include the fluvial-anadromous, lagoon-anadromous, and freshwater life history patterns that can be exhibited by native *O. mykiss* throughout the SCCCS Recovery Planning Area. Achieving this goal will require a number of closely coordinated activities, such as further research into the diverse life history patterns and adaptations of steelhead to a semi-arid and highly dynamic environment including the ecological relationship between non-anadromous and anadromous populations; monitoring of existing populations; and the implementation of the habitat protection and restoration actions would allow focusing on management activities (*e.g.,* removal of physical or hydrologic migration barriers,) to produce the suite of conditions that promote the coexistence of the different life history forms. Research may indicate that not all life history forms may have to be present in all viable populations on a regular basis, but only periodically.

Criteria D.2 – Redundancy and Geographic Separation. Wildfires, droughts, and debris flows pose the greatest natural threats to entire populations. Preservation of the various life history forms of *O. mykiss* requires that not all viable populations in a BPG be extirpated as a result of a natural catastrophic event – this requires both a redundancy of populations and an effective separation of populations. To ensure the survival of a minimum number of viable populations in each BPG, recovered populations should be separated by a sufficient distance to minimize the likelihood that individual wildfires do not encompass the entire suite of watersheds in any BPG. To determine the level of redundancy of viable populations and spatial differentiation between populations necessary to withstand catastrophic wildfires, the expected geographic extent of a thousand-year wildfire was estimated, based on wildfire data from 1910 through 2003. Fire return times were estimated using standards methods, and the number of wildfires that might be expected to affect each BPG was estimated, based on the number of fire-starts per mile in each BPG. From this analysis it was determined that the number of viable populations necessary for each BPG was at least one viable population plus the maximum number of wildfires expected for the BPG, or the number of historic viable populations in the BPG, whichever was less. The minimum geographic distance between individual viable populations, to the maximum extent feasible, should be 42 miles to minimize the likelihood that the minimum number of viable populations would be extirpated by the same thousand-year wildfire event. The preservation of a necessary minimum number of viable populations within a BPG against droughts and debris flows is achieved through the redundancy and geographic separation prescribed to protect against wildfire risk (Boughton *et al.* 2007b).

6.4 THREATS ABATEMENT CRITERIA

The current threat regime that is impeding the ability of anadromous *O. mykiss* to recover must be addressed to meet the population and DPS-level recovery criteria described above. In addition efforts to reduce the threats facing the species must also take into consideration future threats to species recovery such as climate change, ongoing human population growth, and associated land and water developments. Basic threats abatement criteria identified below are used in tracking the success of recovery efforts. The identified existing and future threats fall within the categories of listing factors identified during the species listing process (see Chapters 9 through 12, sub-sections 9.4 – 12.4 for each BPG). Each of these factors must be addressed prior to making a determination that a species

has recovered and no longer requires the protections of the ESA.

This Recovery Plan prioritizes recovery actions for the watersheds within the BPGs according to the role of the watershed in recovery of the species, the severity of the threat addressed by the action, and the listing factors addressed by the action. Each recovery action has been given a priority of 1 or 2 as defined in the NMFS Interim Recovery Planning Guidance (see box, below, for definitions) for purposes of providing general guidance in the implementation of individual recovery actions. Further, a priority 3 ranking has been assigned for all other recovery actions which do not meet the criteria used for priority 1 or 2 recovery actions. Each recovery action has also been qualified with an additional descriptor: A) if the action addresses the first listing factor regarding the destruction or curtailment of the species' habitat; or B) if the action addresses one of the other four listing factors (see Chapter 3, Factors Contributing to Decline and Federal Listing, for definition of listing factors). Where the recovery action addresses both types of listing factors, the descriptor is based on the principal listing factor addressed. Priority 1 recovery actions are necessary to prevent the extinction of the SCCCS DPS or an irreversible decline. Priority 2 actions are intended to avoid prejudicing the recovery of the DPS by ensuring that individual populations essential to recovery are not further degraded or lost. Priority 3 actions are the remainder of the full suite of actions necessary to address all the viability criteria identified for the full recovery of the DPS (including recovery of individual populations identified in Table 7-1).

Priority 1: Actions that must be taken to prevent extinction or to prevent the species from declining irreversibly.

Priority 2: Actions that must be taken to prevent a significant decline in species population/habitat quality or in some other significant negative impact short of extinction.

NMFS proposes that all watershed threats having a priority 1A or 1B recovery actions in core 1 and 2 populations be abated to a "low" level using the same threats assessment process used to establish threat levels for this plan.

In addition, for watershed threats with recovery actions ranked as either priority 2 or 3, the threat must be abated one level below its current threat ranking based on the ranking system used in the threats assessment (*e.g.*, abate from "high" to "medium," or "medium" to "low").

The application of these threats abatement criteria is illustrated in the example in Table 5-2. High-level (red) threats associated with high-priority (1A and 1B) recovery actions are abated to low (green) levels. However, high-level threats associated with secondary (2A and 2B) priority recovery actions need only be abated one threat level to medium (yellow).

Table 6-2. Example application of basic threats abatement criteria.

Threat	Current Threat Level	Recovery Action Rank	Target Abatement Level for Recovery
Culverts and Road Crossings (Passage Barriers)		1A	
Urban Development		1B	
Wildfires		1B	
Roads		2B	
Groundwater Extraction		2B	

The threats abatement criteria are linked to one or more of the listing factors identified for the SCCCS DPS. Only Listing Factor 2, Over-utilization, does not have specific threats abatement criteria identified, as changes in fishing regulations have already ameliorated the threat posed to the species from angling through the prohibition of angling in most anadromous waters within the SCCCS DPS. These threats abatement criteria are intended to ensure that:

- Viable populations have unimpeded access to previously occupied habitats (Listing Factors 1, 4, and 5).
- Freshwater migration corridors supporting viable populations meet the life history and habitat requirements of steelhead (Listing Factors 1, 3, 4, and 5).
- Watersheds supporting viable populations have habitat conditions and characteristics that support all life history stages (Listing Factors 1, 3, 4, and 5).
- Adequate funding, staffing, and training are provided to state and federal regulatory agencies to ensure the ecosystem and species protections of state and federal requirements are properly implemented and remain in place (Listing Factor 4).
- Standardized monitoring of populations and their habitats in each BPG across the SCCCS DPS evaluates the effectiveness of recovery actions and measures progress towards recovery (Listing Factors 4 and 5).

The threat source ranking for each component watershed is presented in BPG Chapters 9-12; a description of the CAP workbook methodology can be found in Appendix D.

7. Steelhead Recovery Strategy

"The aim of the Federal Species Act (ESA) is to recover species that would otherwise go extinct, and to that end it requires the Federal government to prepare recovery plans. A recovery plan outlines a strategy for lowering extinction risk to an acceptable level. . ."

NOAA Fisheries Technical Recovery Team, Population Characterization for Recovery Planning, 2006

7.0 INTRODUCTION

The biological recovery strategy is the approach undertaken to achieve the individual recovery criteria and objectives and, in turn, the ultimate recovery goal of de-listing the SCCCS DPS. The recovery strategy in this Recovery Plan identifies the core watersheds where recovery of viable populations is necessary to achieve the recovery goal and implement watershed-specific actions (*e.g.*, removal of migration barriers, modification of land-use practices, including agriculture, and protection and restoration of spawning and rearing habitats) that are necessary to reverse the effects of past and ongoing threats to population abundance, growth rate, diversity, and spatial structure of threatened steelhead within the SCCCS Recovery Planning Area. An integral element in this recovery strategy is the development and implementation of a research and monitoring program which will provide the additional information necessary to refine recovery criteria and objectives, as well as assess the effectiveness of recovery actions and the overall success of the recovery program.

Recovery of South-Central California Coast steelhead will require an effective implementation, as well as a scientifically sound biological recovery strategy. The framework for a durable implementation strategy involves two key principles: 1) solutions that focus on fundamental causes for watershed and river degradation, rather than short-term remedies; and 2) solutions that emphasize resilience in the face of an unpredictable future to ensure a sustainable future for both human communities and steelhead (Beechie *et al*. 2010, 1999, Boughton 2010a, Boughton *et al.* 2006, 2007b, Lubchenco 1998).

Implementation of this Recovery Plan will require a shift in societal attitudes, understanding, priorities, and practices. Many of the current land and water use practices that are detrimental to steelhead (particularly water supply and flood control programs) are not sustainable. Modification of these practices is necessary to both continue to meet the needs of the human communities of South-Central California and restore the habitats upon which viable steelhead populations depend. Recovery of steelhead will entail significant investments, but will also provide economic and other ecosystem and societal benefits. Restored, viable salmonid populations provide ongoing direct and indirect economic benefits, including recreational fishing, and other tourist related activities. A comprehensive strategic framework is necessary to serve as a guide to integrate the actions contributing to the larger goal of recovery of the SCCCS DPS. This

strategic framework incorporates the concepts of viability at both the population and DPS levels, and the identification of threats and recovery actions for watersheds within each BPG.

7.1 ACHIEVING RECOVERY

For millennia, South-Central California Coast steelhead have successfully dealt with natural environmental fluctuations such as prolonged droughts, flash-floods, uncontrolled wildfires, sea level alternations, periodic massive influxes of sediment to the rivers and streams, and climate changes—natural environmental fluctuations which also currently challenge the human population of South-Central California (Waples *et al.* 2008a, 2008b).

Of the approximately 37 million people currently living in California, approximately 2.8 million live in the South-Central California counties of Santa Cruz, Santa Clara, Monterey, San Benito, and San Luis Obispo. As a result of this large human population, and related development, steelhead populations, along with other indigenous species of both animals and plants, have been severely reduced or extirpated in many coastal watersheds. Despite extensive landscape modifications, steelhead have continued to persist, in one or more of its several life history forms, in portions of many South-Central California watersheds, including some of the most highly urbanized.

Recovery of viable, self-sustaining populations of anadromous South-Central California Coast steelhead will entail the re-integration of these populations into the human configured landscape. Such re-integration will necessarily include an effort to restore habitats and operate the human built system in ways which conserve and better utilize land and water resources in mutually beneficial ways for South-Central California Coast steelhead and the current and projected human population. Uncertain future precipitation and associated wildfires will create challenges in maintaining traditional water supply and flood control structures such as dams, levees, and channelization. Engineered systems which control hydrological systems have often been overvalued, and frequently overwhelmed when their design parameters have been exceeded by natural forces (floods, droughts, wildfires, earthquakes, debris flows, *etc.*). Investments in more sustainable productive capital can at least partially offset these challenges while also providing more suitable habitat conditions for steelhead. Dedicating space for natural stream behavior via setback levees and underground or off-channel water storage are some of the ways to take advantage of the self-organizing capacity of natural systems. Such an approach can offer a more efficient mix of technological and natural capital, and is more likely to be a more economical, self-maintaining strategy (see for example, Mount 1995). Steelhead recovery that is based on watershed and river restoration has the potential to reconcile three conditions: steelhead viability, self-adjustment of stream systems, and the provision of ecological services for people.

Addressing these challenges therefore provides an opportunity to meet a wide variety of public policy objectives to ensure a sustainable future for the threatened South-Central California Coast steelhead, as well as other native riparian species, including a number of other federally listed species such as California red-legged frog, Least Bell's vireo, Arroyo toad, Tidewater goby, and the Western snowy plover that co-occupy the SCCS Recovery Planning Area.

Under present conditions, the viability of individual populations is more likely achievable by focusing recovery efforts on larger watersheds capable of sustaining larger populations, and DPS viability is more likely to be achievable by focusing on the most widely-dispersed set of such core populations capable of maintaining dispersal connectivity between South-Central California coastal watersheds.
Effective implementation of recovery actions will entail: 1) development of cooperative relationships and a shared vision with private

land owners, special districts, and local governments with direct control and responsibilities over non-federal land-use practices to maximize recovery opportunities; 2) participation in the land use and water planning and regulatory processes of local, regional, State, and Federal agencies to integrate recovery efforts into the full range of land and water use planning; 3) close cooperation with other state resource agencies such as the California Department of Fish and Game, California Coastal Commission, CalTrans, and the California Department of Parks and Recreation, State Water Resources Control Board, and Regional Water Quality Control Boards to ensure consistency of recovery efforts; and 4) partnering with federal resource agencies, including the U.S. Forest Service, U.S. Fish and Wildlife Service, National Park Service, U.S. Bureau of Reclamation, U.S. Bureau of Land Management, U.S. Army Corps of Engineers, U.S. Department of Transportation, U.S. Department of Defense, and the U.S. Environmental Protection Agency to utilize agencies' expertise and resources. To support all of these efforts, NMFS and its partners will need to provide technical expertise and public outreach and education regarding the role and value of the species within the larger watershed environment and the compatibility of sustainable development with steelhead recovery.

An implementation schedule describing time frames and estimated costs associated with individual recovery actions has been developed. Estimating time and total cost to recovery is challenging for a variety of reasons. These reasons include the large geographic extent of the SCCCS Recovery Planning Area; the need to refine recovery criteria; the need to complete watershed-specific investigations such as barrier inventories and assessments; the establishment of flow regimes for individual watersheds; and the review and possible modification of a variety of existing land-use and water management plans (including waste discharge requirements) under a variety of local, state, and federal jurisdictions. Additionally, the biological response of many of the recovery actions is uncertain, and achieving full recovery will be a long-term effort likely requiring decades, while addressing new stressors that emerge over time. However, NMFS estimated the costs associated with certain common restoration activities such as those undertaken as part of the California Department of Fish and Game Fisheries Restoration Grants Program. Appendix E, Habitat Restoration Cost References For Steelhead Recovery Planning, contains preliminary estimates for these categories of typical watershed and river restoration actions.

7.2 CORE POPULATIONS

The findings of the TRT (Boughton *et al*. 2007b, 2006) and additional review by NMFS indicate certain watersheds and the steelhead populations within those watersheds constitute the foundation of the recovery of the SCCCS DPS. (See Table 7-1). These watersheds exhibit the physical and hydrological characteristics (*e.g.,* large spatial area, perennial and reliable winter streamflow, stream network extending inland) that are most likely to sustain independently viable populations, and that are critical for ensuring viability of the DPS as a whole. Population viability is more likely achievable by focusing recovery efforts on larger watersheds in each Biogeographic Population Group capable of sustaining larger populations, and DPS viability is more likely achievable by focusing on the most widely-dispersed set of such core populations capable of maintaining dispersal connectivity (see Boughton *et al.* 2007b, 2006).

In Table 7-1 populations are identified as Core 1, Core 2, or Core 3.[1] The Core 1 populations are those populations identified as the highest

[1] The minimum number of recovered populations identified in Table 7.1 is comprised of a combination of Core 1, 2, and 3 populations.

priority for recovery actions based on a variety of factors, including: the intrinsic potential of the population in an unimpaired condition; the role of the population in meeting the spatial and/or redundancy viability criteria; the current condition of the populations; the severity of the threats facing the populations; the potential ecological or genetic diversity the watershed and population could provide to the species; and the capacity of the watershed and population to respond to the critical recovery actions needed to abate those threats. The weight given these factors in designating populations as either Core 1 or Core 2 may vary with individual watersheds. Generally larger watersheds with the highest intrinsic potential, such as the Salinas and Pajaro, have been designated Core 1 populations. However, smaller watersheds such as San Carpoforo or Arroyo de la Cruz Creeks which may contain high quality habitat but are not be subjected to existing or future threats similar to other comparable watersheds may be classified as Core 2 populations. This approach to designating Core Populations is intended to focus recovery efforts on populations which are essential to the recovery of the DPS as well as on watersheds which are have the highest need for recovery action. Core 1 populations form the nucleus of the recovery implementation strategy and must meet the population-level biological recovery criteria set out in Chapter 6, Steelhead Recovery Goals, Objectives & Criteria, Table 6-1. This set of Core 1 populations should be the first focus of an overall recovery effort; however, NMFS also recognizes that the timing of such efforts may be influenced by practical considerations such as the availability of funding, environmental review and permitting requirements, as well as willing and able partners. Core 2 populations also form part of the recovery implementation strategy and contribute to the set of populations necessary to achieve recovery criteria such as minimum numbers of viable populations needed within a BPG. Similar to Core 1 populations, Core 2 populations must meet the biological recovery criteria for populations set out in Table 7-1; while these populations are ranked slightly lower than Core 1 populations based on the factors noted above, NMFS recognizes that the timing of recovery actions on these populations may be influenced by practical considerations such as the availability of funding, environmental review and permitting requirements, and willing and able partners. While recovery actions on Core 3 populations are not assigned as high an implementation priority as Core 1 and 2 populations, these populations could be important in promoting connectivity between populations and genetic diversity across the SCCCS Recovery Planning Area, and therefore are an integral part of the overall biological recovery strategy.

Populations identified in Table 7.1 as Core 1 and 2 populations should meet the four population recovery criteria either as a single population or a group of interacting trans-watershed populations such as those that might exist in the Big Sur Coast and San Luis Obispo Terrace BPGs. Core 3 populations, because of their generally lower intrinsic potential, may function as part of an interacting trans-basin population, but do not meet all the population viability criteria as individual populations. Further research is needed to identify these interacting groups, and the population characteristics which they must exhibit to ensure viability of the DPS.

The TRT recommended that a critical component of the recovery strategy should be to secure the extant inland populations of the species: Interior Coast Range BPG (Pajaro and Salinas Rivers) and the Carmel Basin BPG (Carmel River). The number of original inland populations was small, large in spatial extent, and inhabited challenging environments. Due to low redundancy they are necessarily Core 1 populations in the sense described above. Yet the populations of the Interior Coast Range and Carmel Basin BPGs appear to have produced the largest run sizes in the SCCCS DPS during years of high rainfall and run-off (Boughton *et al.*, 2006, Good *et al.*, 2005). The extant habitat of

these populations–especially the anadromous waters of the Pajaro, Arroyo Seco, and Salinas Rivers–merit high priority for immediate protection and restoration so that fish runs do not decline further. The low level of redundancy in these BPGs indicates that ongoing efforts to restore flows and fish passage in the Pajaro and Salinas Rivers are necessary steps to achieving DPS viability, as are efforts to improve flows and fish passage in the Carmel River Basin.

Table 7-1. 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.

BPG	POPULATION	FOCUS FOR RECOVERY
Interior Coast Range	**Pajaro River watershed (all populations)**	**Core 1**
	Salinas River watershed (all populations)	**Core 1**
Carmel River Basin	**Carmel River**	**Core 1**
Big Sur Coast	**San Jose Creek**	**Core 1**
	Garrapata Creek	Core 2
	Rocky Creek	Core 3
	Bixby Creek	Core 2
	Little Sur River	**Core 1**
	Big Sur River	**Core 1**
	Big Creek	Core 3
	Limekiln Creek	Core 3
	Prewitt Creek	Core 3
	Willow Creek	Core 3
	Salmon Creek	Core 3
San Luis Obispo Terrace	San Carpoforo Creek	Core 2
	Arroyo de la Cruz	Core 2
	Little Pico Creek	Core 2

	Pico Creek	Core 2
	San Simeon Creek	**Core 1**
	Santa Rosa Creek	**Core 1**
	Villa Creek	Core 3
	Cayucos Creek	Core 3
	Toro Creek	Core 3
	Old Creek	Core 3
	Morro Creek	Core 3
	Morro Bay Estuary Chorro Creek Los Osos Creek	Core 2
	San Luis Obispo Creek **Pismo Creek** **Arroyo Grande Creek**	**Core 1** **Core 1** **Core 1**

**Note: If further research determines that individual populations are not viable, restoration of more closely spaced populations may be required to achieve the minimum number of viable populations for this BPG.*

Public and private groups should not be dissuaded from undertaking actions that alleviate threats to the species in Core 3 watersheds (or other steelhead bearing watersheds within the SCCCS DPS such as Big, Villa, Old, or Toro Creeks) because of their potential role in contributing to the overall abundance and diversity of the SCCCS DPS, as well as promoting connectivity between populations. While sufficient information regarding threats and the biology and ecology of the species is available to define an overall recovery strategy, there still remain questions regarding the ecology of the species (*e.g.*, function of certain habitats in the life history of the species, relationship between the anadromous and resident forms, rate of dispersal between watersheds). In light of this uncertainty, a prudent approach is to define a recovery strategy based on the existing information on Core 1 and 2 watersheds while recovery opportunities in Core 3 watersheds continue to be actively pursued as a precaution to reduce the risk of extinction. Therefore, while the Core 1 and 2 watersheds form the foundation for recovery of the SCCCS DPS, recovery actions to alleviate threats should be undertaken in other watersheds to complement this recovery implementation strategy.

7.3 CRITICAL RECOVERY ACTIONS

The recovery actions in this recovery strategy represent the critical elements for alleviating major threats to threatened steelhead in core watersheds. Recovery actions are also specified to address limited knowledge regarding the biology and ecology of the species, as well as its changing status within individual core watersheds.

Critical recovery actions should have the highest priority across the SCCCS DPS and within core watersheds to achieve recovery objectives and criteria. In the tables describing recommended recovery actions for populations within the DPS, these actions have received a priority ranking of

1. Opportunistically, other recovery actions may be implemented prior to these actions, but these actions are widely recognized in the scientific literature as addressing threats which have caused the wide-spread decline of steelhead throughout its natural range. See for, example, Moyle *et al.* (2011, 2008), Johnson *et al.* (2008), Caudill *et al*. (2007), Gustafson *et al.* (2007), Cooke *et al. (*2006), Boughton *et al.* (2005), Brown *et al.* (2005), Doyle *et al. (*2003), Williams and Bisson (2003), Hart *et al.* (2002), Bednarek (2001) Pejchar and Warner (2001).

A wide range of anthropogenic activities have contributed to the high extinction risk of the SCCCS DPS, and the significant of each activity varies considerably between watersheds. In some watersheds such as the Pajaro and Salinas, agricultural activities (and related flood control and water management practices have had a significant impact on steelhead habitat. However, two types of developments and activities generally pose the most widespread threats to the species: 1) impassable barriers, and 2) water storage and withdrawal, including groundwater extraction (see Chapter 4, Current DPS-Level Threats Assessment, Table 4-1). These threats affect basic life history phases of the species (egg-to-smolt survival and smolt-to-spawner survival) throughout the DPS and are key components of the risks posed to the species. Accordingly, this recovery strategy places a high priority on recovery actions that alleviate threats related to impassable barriers and water storage and withdrawal. Closely related to providing access to rearing habitats is the need to ensure that the ecological functions of those habitats are protected and, where impaired, are restored. The critical recovery actions to address these two threats within the Core 1 watersheds are listed below in Table 7-2. Additionally, land-use practices, including agricultural practices in the Pajaro, Salinas and Arroyo Grande watersheds have severely degraded mainstem and estuarine habitats and are identified as high threat sources with corresponding high priority recovery actions in each respective BPG, with corresponding high priority recovery actions in Tables 9-4 through 9-6, and Tables 12-4 through 12-13.

Regarding the effects 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 to allow the species sustainable natural access to historical spawning and rearing habitats. Historical habitats are often situated in protected areas such as U.S. National Forests, and exhibit essential characteristics such as suitable substrate, sustained base flows, and refugia such as pool habitats. Besides allowing access to historical habitats, dam modification provides additional ecological benefits that are essential to attaining the recovery objectives. Such benefits include maintaining genetic and ecological diversity, population abundance, growth rates, and buffering against natural and anthropogenic catastrophic disturbances (*e.g.*, wildfires, droughts, debris flows) though restoration of the natural spatial population structure of the SCCCS Recovery Planning Area. Mechanistic solutions to fish passage can be problematic for a variety of reasons, including: the limitations in the operations during high flows when fish are most likely to be migrating; periodic mechanical failures which result in migration delays, or lost migration opportunities; and the expense of personnel and equipment to maintain such operations. See for example, Keefer *et al*. 2008, Caudill *et al*. (2007), Pompeu and Martinez (2007), Oldani and Baigum (2002), Nemeth and Kiefer (1999), Cada *et al.* (1995, 1993), Colt and White (eds.) (1991), Fleming *et al. (*1991), Godinho *et al.* (1991), Lucas and Baras (2001). If barrier modification (including removal or breaching) is determined to be technically or otherwise infeasible, alternative approaches for providing effective passage of steelhead should be implemented. The selected alternatives should provide the full

range of ecological benefits associated with barrier removal, breaching, or modification.

Water storage (including reservoirs and managed groundwater basins) and withdrawals (*e.g.,* groundwater pumping, surface-water diversions) can alter the pattern and magnitude of streamflow, with multiple adverse effects to steelhead habitats, including, but not limited to: reducing migratory conditions, degrading spawning and rearing habitat, facilitating the colonization by non-native species, and altering the physical and biotic habitat structure which supports the ecosystem upon which steelhead depend. See for example, Wegner *et al.* (2011, 2010), Marks *et al.* (2010), Poff and Zimmerman (2010), Poff *et al.* (2010, 1997), Annear *et al*. (2009), Instream Flow Council (2009), Olden and Naiman (2009), Lytle and Poff (2004), Bunn and Arthington (2002), Gibbons *et al.* (2001), Hatfield and Bruce (2000), Vadas (2000), Kraft (1992), MacDonald *et al*. (1989).

Recovery of the SCCCS DPS requires the restoration of steelhead distribution to previously occupied areas and the restoration of suitable habitat conditions and characteristics for all life history stages of steelhead. Threats abatement criteria identified to meet these objectives include the restoration and protection of these habitat conditions and characteristics. The essential recovery actions involve either halting the alteration of the pattern and magnitude of streamflow when such an option is available, or implementing measures (*e.g.,* operating criteria) to ensure that a more natural (*i.e.,* timing, frequency, duration, magnitude, and rate-of-change) streamflow is restored. There are many sites within core watersheds where past and present anthropogenic activities continue to alter the pattern and magnitude of streamflow and for which essential recovery actions are identified. In some situations, other actions to address impassable barriers may fully or partially eliminate threats to the pattern and magnitude of streamflow, thereby addressing two principal threats to the species: physical blockage of fish passage, and reduction or elimination of surface flows. The restoration of a more natural flow regime will also contribute toward restoring rearing habitats.

Regarding rearing habitats, rapid juvenile growth is one of the most effective strategies for successfully completing the early life history stages (fertilized egg to smolt) of the anadromous life history form, and ensuring survival during the ocean phase prior to return as spawning adults. Studies have demonstrated high growth rates in some seasonal lagoons, and possibly other freshwater habitats that provide suitable over-summering habitat (Hayes *et al.* 2011b, 2008, Casagrande 2012, 2010, Bond 2006, Smith 1990, Moore 1980). The identification, protection, and where necessary, restoration of such habitats is therefore another critical recovery action.

The high priority recovery actions identified in the Recovery Plan do not diminish the importance of continuing to undertake actions that, while not the focus of this recovery strategy, promote the restoration and maintenance of essential habitat functions for individual populations within the SCCCS Recovery Planning Area. Resource managers and stakeholders should continue to implement recovery actions that: 1) curb unnatural inputs of fine sediments to waterways, 2) promote the establishment and maintenance of streamside vegetation and flood-plain connectivity and function, and 3) encourage the formation and preservation of complex instream habitat. To reduce further degradation of habitat characteristics and condition in watersheds throughout the entire range of the DPS, local stakeholders should continue to undertake those actions that complement the essential recovery actions in Core 1 watersheds.

Finally, conservation hatcheries may contribute to the recovery of the SCCCS DPS in a variety of ways, including: (1) providing a means to preserve local populations faced with immediate extirpation as a result of catastrophic events such as wildfires, toxic spills, dewatering of

watercourses, etc.; 2) preserve the remaining genotypic and phenotypic characteristics that promote life history variability though captive broodstock, supplementation, and gene-bank programs to reduce short-term risk of extinction; and 3) reintroduction of populations in restored watersheds.

Issues that should be considered prior to implementing a conservation hatchery program include: 1) conditions under which rescue, reestablishment or supplementation could be used effectively in wild steelhead recovery, 2) methods for rescue, reestablishment or supplementation, and 3) protocols for evaluating the effectiveness of such conservation hatchery functions over time. (See Chapter 8, Summary of DPS-Wide Recovery Actions, Sub-section 8.3 for additional discussion of the role of conservation hatcheries in steelhead recovery.) Conservation hatcheries and species' establishment program should not serve as surrogates for establishing and preserving essential habitat functions for threatened steelhead particularly where anthropogenic activities have created threats that constrain or eliminate habitat functions and values.

Table 7-2. Critical recovery actions for Core 1 *O. mykiss* populations within the South-Central California Coast Steelhead DPS.

BPG	POPULATION	CRITICAL RECOVERY ACTIONS
Interior Coast Range	Pajaro River	Implement operating criteria to ensure the pattern and magnitude[1] of groundwater extractions and water releases from Uvas Dam and Pacheco Dam to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify[2] fish passage impediments, including Uvas Dam and Pacheco 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 ocean. Manage instream mining to minimize impacts to migration, spawning and rearing habitat.
	Salinas River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases from the Salinas, Nacimiento, and San Antonio Dams to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify fish passage impediments, including Salinas Dam and downstream passage impediments 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.
	San Antonio River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions from San Antonio Dam to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify fish passage impediments, including 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 ocean.
	Nacimiento River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, from Nacimiento Dam to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify fish passage impediments, including 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 ocean.
Carmel River Basin	Carmel River	Implement alternative off channel water supply projects to eliminate or decease water extractions from the channel (including subsurface extractions), and implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, from San Clemente and Los Padres Dams to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove fish passage impediments, including San Clemente and Los Padres Dams 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
Big Sur Coast	San Jose Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage impediments 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.

	Little Sur River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage impediments, including dams and diversions, 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. Manage roads to minimize sedimentation of spawning and rearing habitat. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
	Big Sur River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage impediments 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
San Luis Obispo Terrace	San Simeon Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage to allow steelhead impediments natural rates of migration to upstream spawning and rearing habitats, and passage of smolts and kelts downstream to the estuary and ocean. Manage instream mining to minimize impacts to migration, spawning and rearing habitat. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
	Santa Rosa Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage impediments 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
	San Luis Obispo Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage impediments, including dams and diversions, 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
	Pismo Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage impediments, including dams and diversions, 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
	Arroyo Grande Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage impediments, including dams and diversions, 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.

[1] *"Pattern and magnitude" refers to timing, duration, frequency, magnitude, and rate-of-change.*
[2] *Physically modifying a dam may incidentally restore the natural or pre-dam pattern and magnitude of streamflow.*

7.4 RESTORING STEELHEAD ACCESS TO HISTORICAL HABITATS THAT ARE CURRENTLY INACCESSIBLE AND UNOCCUPIED BY THE SPECIES

Steelhead are a highly migratory species, allowing them to move between marine and freshwater habitats to gain access to spawning and rearing habitats, and productive marine foraging areas (Quinn 2005). Much of this movement within freshwater habitats has been restricted by a variety of barriers to migration (California Department of Fish and Game 2011b; see Figures 7-1 and 7-2). Restoring steelhead access to historical spawning and rearing habitats (*i.e.,* areas upstream of introduced barriers that are currently unoccupied by anadromous *O. mykiss*) is an essential action for recovering threatened steelhead.

The following discussion summarizes the ecological rationale for this specific recovery action. Central to the rationale is the historical steelhead population structure and distribution, and the necessity of historical habitats for reducing extinction risk and increasing population growth rate (*i.e.,* the productivity of a population).

Unoccupied areas are essential for conserving threatened steelhead (Boughton *et al.* 2007b, 2006). The characteristics and condition of historical habitats must remain functional to support their intended conservation role for the species. Implementing these essential recovery actions will require removing or physically modifying anthropogenic barriers, which NMFS expects will generate questions regarding the feasibility of undertaking such activities. In response to such questions, we summarize information here that indicates barrier removal and physical modification would be feasible and successful (*i.e.,* would increase population growth rates).

Native steelhead historically existed in areas that are currently inaccessible.

Knowing where the species existed prior to the construction of migration barriers is essential for identifying the watersheds where restoring access to historical spawning and rearing habitats would be appropriate.

A review of the scientific and historical literature on the distribution of steelhead within the SCCCS Recovery Planning Area indicates that the species was widespread up until the mid-20th century. See for example, Becker *et al*. (2008), Boughton *et al.* (2007c), Boughton *et al.* (2005), Boughton and Fish (2003), Swift *et al.* (1993), Nehlsen, *et al.* (1991), Wells *et al.* (1975), Boydstun (1973), Fry (1973), Shapovalov *et al*. (1981), Combs (1972), Fry (1938, 1973), Kreider (1948), Hubbs (1946), Jordan and Gilbert (1881), and Jordan and Evermann (1896, 1923).

Investigation of the genetic structure of juvenile *O. mykiss* collected from freshwater habitats, including instream areas upstream of migration barriers within Core 1 populations, confirm that the present-day populations are dominated by ancestry of indigenous South-Central coastal steelhead (Clemento *et al.* 2009, Pearse and Garza 2008, Girman and Garza 2006, Nielsen *et al.*2001, 1997, 1994c). Populations of *O. mykiss* that exist upstream of introduced barriers are largely or entirely descended from relic *O. mykiss* populations ascending the watersheds historically. These findings as well as the intrinsic potential of certain watershed-specific populations for recovering this species support the high priority of restoring steelhead access to upstream spawning and rearing areas, especially within Core 1 populations (Boughton *et al*. 2007b, 2006, Boughton and Goslin 2006).

Restoring species access to historical habitats will reduce extinction risk and increase population growth rate.

Artificial migration barriers are a major cause of habitat loss and fragmentation within the

SCCCS Recovery Area, and have resulted in a high risk of species' extinction (Hunt & Associates 2008a, Boughton *et al.* 2005). Restoring steelhead access to historical habitats is necessary to reduce extinction risk to a level that is considered negligible over a 100-year period. See Figures 7-2 and 7-3.

Population extinction risk is related to the numerical abundance of the population, which itself is related to the extent that the species is distributed over space (*i.e.,* population spatial structure) and the degree to which diversity of life history traits is not restricted. Small populations with limited spatial structure are particularly susceptible to extinction, owing to their increased susceptibility to demographic and environmental fluctuations, and loss of genetic variability. Steelhead exhibit a suite of traits, such as anadromy, timing of spawning, emigration, and immigration, fecundity, age-at-maturity, and other behavioral, physiological and genetic characteristics. The variable of these characteristics reflect their adaptation to their variable freshwater and marine environments. The more diverse these traits (or the more these traits are not restricted), the more likely the species is to survive a spatially and temporally fluctuating environment (Boughton *et al.* 2006, McElhany *et al*. 2009, 2000). Overall, the greater a species' geographic distribution and the less constrained the diversity of life history traits, the more likely the species' ability to withstand stochastic environmental variation and achieve and maintain a rate of population growth that is viable (*i.e.,* reduces the extinction risk to a negligible level).

Throughout the SCCCS Recovery Planning Area, anthropogenic activities have severely truncated population spatial structure through the construction of structures that have inhibited or blocked completely fish migration, and as a result eliminated certain life history traits, particularly the anadromous life history form which has been classified as threatened in the SCCCS Recovery Planning Area. See for example, California Department of Fish and Game (2011b), Boughton *et al.* (2005).

While the species was historically widespread, artificial migration barriers have resulted in populations that are sparsely distributed over space and significantly reduced in both the size and number of populations. These barriers prevent steelhead from migrating within rivers and to and from the ocean, a critical part of the species' life cycle. Barriers preclude steelhead from accessing upstream spawning habitats and interacting with the freshwater form of *O. mykiss*, which can contribute to the diversity of the O. mykiss complex, and better withstand stochastic environmental fluctuations.

Because the limited and degraded habitat conditions within the SCCCS DPS has reduced the abundance, diversity, spatial structure, and growth rate of the affected steelhead populations, the areas currently occupied by the species are inadequate for recovery of the species (Boughton *et al*. 2007b, 2005, Gustafson *et al*. 2007, Boughton *et al*. 2005, Good *et al.* 2005).

An effective recovery strategy for increasing population growth rate and reducing extinction risk to a level that is considered negligible over a 100-year period is to re-establish access to habitats historically use by steelhead and restoring ecological traits that are necessary for the species to express its variable and complex life cycle.

Habitats within inaccessible areas are capable of supporting essential life history functions.

The available information describing the current abundance and distribution of *O. mykiss* indicates that habitats historically accessible to steelhead possess the capacity to support production of steelhead. Investigators commonly use information on the abundance or distribution of stream fish as a means to infer the existence of suitable habitat for a species (Boughton and Goslin 2006, Thomas R. Payne and Associates 2004, 2001, 2000). Fishery

investigations performed in selected coastal watersheds by state and federal resources agencies, as well a variety of academic and private investigators, report on the distribution of *O. mykiss* habitat, including in areas upstream of artificial barriers within Core 1 populations. These investigations indicate that the existing habitats are suitable for spawning and rearing of *O. mykiss*, as evident by the finding of young-of-the-year and older juvenile trout. Inferring the existence of suitable habitat for the anadromous form of *O. mykiss* based on the presence of the resident form is reasonable and ecologically appropriate given that the resident and anadromous forms represent different life history strategies of the same species. See for example, Titus *et al. (*2010), Boughton and Goslin (2006), California Department of Fish and Game (2006), Thomas R. Payne and Associates (2005).

With regard to the amount of suitable steelhead habitat, the findings of fishery investigations and habitat evaluations indicate the existence of hundreds of miles of stream network across the Core 1 populations. Numerous streams within Core 1 watersheds provide an extensive habitat that is capable of supporting spawning and rearing large numbers of steelhead when water and other environmental conditions are suitable. See for example, Casagrande 2011, Smith 2007a, Close 2004, Denise Duffy & Associates 2003, D. W. Alley & Associates 2008, 2007, 2006a, 2006b, 2001, 1997, 1996, Nelson *et al*. 2006a, 2006b, 2005a, 2005b, Thomas R. Payne and Associates 2004, 2001, Hagar 2001, Londquist 2001, Alley Associates 1998, Dettman and Kelley 1986

Restoring steelhead migration to historical habitats upstream of anthropogenic barriers is expected to be feasible and successful.

While implementing the barrier recovery actions will not be without logistical and technical challenges, NMFS' experience as well as the available information regarding fish passage at man-made structures indicate implementation is feasible and would be successful with adequately designed and operated facilities or programs.

Regarding the technical feasibility, physically modifying or partially or completely removing dams, diversions, grade-control structures, and highway crossings for the purpose of restoring upstream migration of steelhead, situations vary significantly and projects must be evaluated on a case-by-case basis, usually with extensive site-specific investigations. However, over the last decade, the removal and modification of dams and other instream structures has accelerated, and the experienced gained in this effort has led to a growing understanding of the technical, logistical and regulatory issues of these types of projects to restore habitat characteristics and conditions for populations of stream fish. See for example, Service (2011), Downs *et al.* (2009), Johnson *et al.* (2008), Keefer *et al.* (2008), Grant (2005), Doyle *et al.* (2003), Graf (2003, 2002, 1999), Kondolf *et al*. (2003, 1997), Williams and Bisson (2003), American Rivers (2002), Aspen Institute (2002), Hart *et al.* (2002), Pizzuto (2002), Bednarek (2001), Dambacher *et al*. (2001), Pejchar and Warner (2001), Stanley and Doyle *(*2003), Smith *et al*. (2000).

Regionally, NMFS has collaborated with project proponents on a variety of fish-passage projects that have involved removal or modification of a highway structure, diversion, or dam for the purpose of either improving or restoring migration of steelhead to historical spawning and rearing habitats. NMFS is currently collaborating with stakeholders on the restoration of river ecosystems including the removal of dams on the Carmel and Ventura Rivers in California, and on the Elwha River in Washington, which require the removal of these dams to allow anadromous salmonids natural access to historical spawning and rearing habitats (Capelli 2007, Wunderlich *et al.* 1994).

With regard to the expected success from restoring steelhead migration to historical habitats, the available information indicates that restoring steelhead access to historical spawning and rearing habitats would increase population growth rate and abundance. Making barriers passable for migratory species effectively

increases breeding and living space for the species. Given the extensive amount spawning and rearing habitat upstream of the barriers within Core 1 populations it can be anticipated that steelhead productivity will increase substantially when access to this habitat is restored.

Significantly, historical habitats currently serves as a refuge freshwater habitat that likely contributes to the conservation of the anadromous form of the species (Boughton *et al.* 2006). *O. mykiss* found above artificial barriers exhibit ancestral native steelhead genetics (Clemento *et al.* 2009). These fish possess the ability to transform into smolts and migrate to the ocean (Thrower *et al*. 2004a, 2004b, 2004c). Even today, large adult *O. mykiss* leave the freshwater lakes that have formed behind dams and undertake steelhead-like migrations during the wet season and spawn in upstream tributaries (M. Capelli, personal communication).

Besides increasing population growth rate, restoring steelhead access to historical spawning and rearing habitats within Core 1 populations is expected to produce four additional benefits for buffering the species against extirpation (these benefits further underscore the necessity and value of unoccupied areas for conserving threatened steelhead).

First, there would be an increase in population spatial structure. The spatial structure of a population is important because it can affect evolutionary processes and therefore alter the ability of a population to adapt to spatial or temporal changes in the species' environment. Populations that are thinly distributed over space are susceptible to experiencing poor population growth rate and loss of genetic diversity, and are more likely to be adversely effected by widely fluctuating environmental conditions.

Second, ecological interactions between the resident and anadromous form of *O. mykiss* would be restored, thereby contributing to the viability of the anadromous form. The two life history forms can be sympatric and genetically similar (McPhee *et al*. 2007, Narum *et al*. 2004, Docker and Heath 2003) and the resident form can produce anadromous progeny and vice versa (McPhee *et al*. 2007, Zimmerman and Reeves 2000). These findings underscore the survival advantage of the resident form to the anadromous form of *O. mykiss*, particularly under certain environmental conditions. For example, extended periods of no or low rainfall can limit migratory conditions and preclude steelhead from reaching freshwater spawning areas. Linked poor ocean conditions can inhibit the growth and maturation of the anadromous form while not adversely affecting the freshwater form of O. mykiss (Mantua 2010, 2002, 1997). During such periods, resident *O. mykiss* may be the only life history form of *O. mykiss* spawning and producing progeny - with the innate ability to resume anadromy - that favors future persistence of the anadromous form. Conversely, the anadromous form can re-colonize watersheds following periods of extended drought and temporary extirpation of the resident form of *O. mykiss*.

Third, restoring steelhead access to historical spawning and rearing habitats upstream of artificial migration barriers would promote ecological traits (phenotypic and genotypic) that must be represented and maintained to promote long-term viability of the species (Boughton *et al*. 2007b). Some of these traits involve the capability to migrate long distances and tolerate elevated water temperatures. Many coastal watersheds supporting Core 1 populations extend considerably inland, which requires that steelhead have the physical ability to migrate long distances to access spawning areas in upper reaches of these watersheds. The ability to migrate long distance promotes population diversity. Because these same populations extend into areas that are dry and warm, populations are exposed to environmental conditions that promote formation of specific adaptations such as the ability to tolerate hot and dry climates. The ability to migrate long

distances and occupy and use diverse habitats promotes genetic and ecological diversity by subjecting the species to a wide variety of selective pressures.

Fourth, the expected increase in population growth rate has the potential to increase abundance in neighboring Core 2 and Core 3 populations. When restored to an "unimpaired" condition, Core 1 populations are expected contribute steelhead to adjacent watersheds through natural dispersal. Contributing to the maintenance of populations in adjacent watersheds effectively increases the total numbers of individuals in the SCCCS DPS. Given the risk of extinction that small populations face (Pimm *et al*. 1988, Primack 2004, Wilson 1971), a larger number of individuals decrease the risk of extinction.

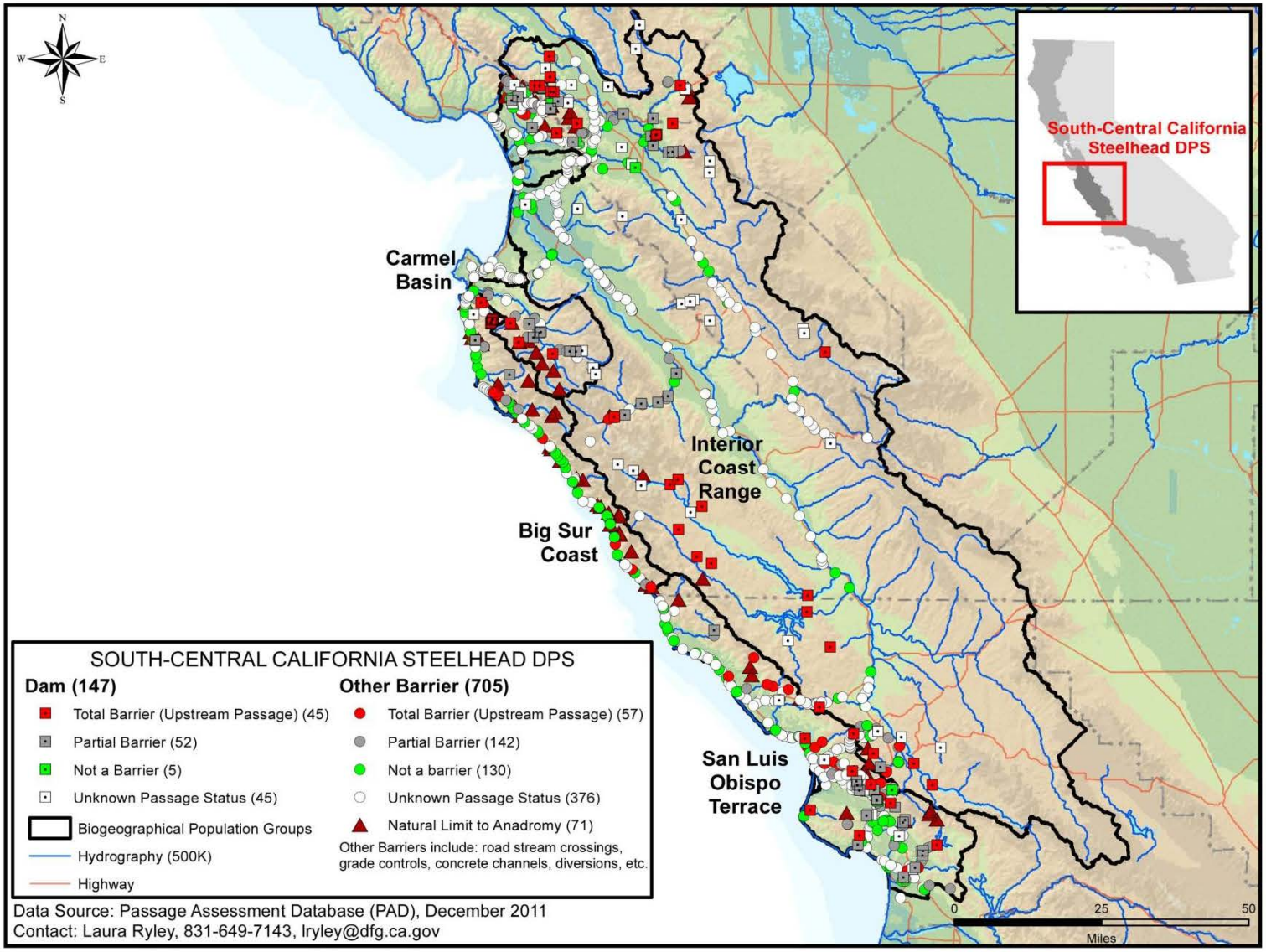


Figure 7-1. South-Central California Coast Steelhead DPS Known and Potential Fish Passage Barriers.

7.5 RECOVERY STRATEGIES TO ADDRESS CLIMATE CHANGE AND MARINE ENVIRONMENT VARIABILITY

Climate change and the conditions in the marine environment are driven by processes on a global scale and are generally not amenable to direct management on a regional scale such as the SCCCS Recovery Planning Area (Riggs, 2004, 2002). However, recognizing the potential challenges posed by climate change and related conditions within the marine environment is useful in designing a recovery strategy which has the greatest likelihood of achieving recovery of the species. Species can respond to climate change in three basic ways: 1) evolve or rely on existing adaptations; 2) colonize new locations with suitable habitat; and 3) go extinct. Given the uncertainties regarding climate change scenarios and localized responses, the most precautionary recovery strategy is to maximize the pathways for adapting and/or colonizing habitats. The two essential components that address the potential adverse effects of climate change on the species freshwater and marine environment are (Boughton 2010a, 2007a):

1. Protect habitat by ameliorating existing and future anthropogenic threats and improve current habitat conditions.

This component encompasses such restoration activities as removing passage barriers to prime upstream spawning and rearing habitats; restoring flow regimes that are essential for both adult and juvenile instream migration; regulating flood control and other instream activities that disrupt river and riparian habitats; and restoring and managing estuarine habitats to ensure that they provide acclimation and rearing opportunities.

2. Establish broadly distributed viable populations within each Biogeographic Population Group by protecting and restoring functional habitat conditions, and controlling and abating existing and future threats.

The over-arching recovery strategy of protecting and restoring multiple populations across the diverse landscape characteristic of the SCCCS Recovery Planning Area is intended to allow the species to continue to evolve adaptations to cope with a dynamic and challenging environment.

Within this basic framework, the Recovery Plan identified specific recovery actions within watersheds of each of the five Biogeographic Population Groups which are intended to address and ameliorate specific adverse effects from projected climate change and related oceanic conditions; most significantly, these include impacts on stream flows, wildfires, riparian habitats, and estuaries. The population and DPS-level biological recovery criteria are intended to establish a threshold for recovery that will ensure the species will persist over an extended period of time, and through long-term (decadal) marine cycles. South-Central California Coast steelhead have evolved a wide variety of life history patterns to exploit the diversity and range of habitat and habitat conditions characteristics of the vegetation, geology, hydrology, and climate characteristics across the SCCCS Recovery Planning Area. The preservation of such life history patterns is essential to the recovery and long-term conservation of the species.

7.6 CRITICAL RESEARCH NEEDS FOR RECOVERY

Successful implementation of the recovery plan and measurement of the species' progress towards recovery requires two critical elements of scientific research and monitoring: 1) population abundance monitoring (including rearing juveniles, smolts, and returning adults) within core watersheds and 2) other research efforts in core watersheds to develop more refined biological recovery criteria. As discussed in Chapter 6, Steelhead Recovery Goals,

Objectives & Criteria, and Chapter 13, South-Central California Coast Steelhead Research, Monitoring and Adaptive Management, long-term and consistent population abundance monitoring is necessary to further refine biological recovery criteria such as the mean annual run size. This monitoring can also measure the effectiveness of restoration and recovery efforts within particular watersheds and shed light on the influence of freshwater and marine environmental factors on the long term survival and recovery of steelhead in South-Central California.

Research efforts should be focused on developing a better understanding of the following topics: 1) reliability of migration corridors; 2) productivity of freshwater tributary nursery areas; 3) evaluation of role of seasonal lagoons, particularly for juvenile rearing; 4) productivity of freshwater mainstem habitats; 5) roles of intermittent freshwater habitats for both spawning and rearing; 6) spawner density as an indicator of individual population viability; 7) relationship between anadromous (steelhead) and non-anadromous (resident) forms and population structure and viability; and, 8) rates of dispersal between individual populations.

With respect to topics 2 through 4, the aim is to identify, protect, and, where necessary, restore those habitats which specifically facilitate the anadromous life history form by, among other things, producing a high number of fast-growing and large smolts, and avoid inadvertently promoting only the freshwater life history form of *O. mykiss*. In addition to these biological research topics, research into basic habitat dynamics should be conducted to provide additional direction in habitat protection and restoration. Such research includes the effects of the wildland fire regime and climate change effects on freshwater habitat; environmental factors that affect freshwater temperatures; and factors producing freshwater refugia that sustain *O. mykiss* during seasonal or prolonged droughts. See Chapter 13, South-Central California Coast Steelhead Research and Monitoring and Adaptive Management, for a further discussion.

8. Summary of DPS-Wide Recovery Actions

"The basic recovery strategy . . . mimics the strategy that the species exhibits in its natural distribution among the various watersheds in their unaltered state, and provides the most effective strategy . . . to ensure the long-term viability of individual populations, and the listed species as a whole."

South-Central California Coast Steelhead Recovery Planning Area: Recovery Actions
Hunt & Associates 2008

8.0 INTRODUCTION

The SCCCS Recovery Planning Area is characterized by severe to very severe degradation of habitat conditions along the lower mainstem river channels where development is concentrated, while the upper mainstem and tributaries, often situated within the Los Padres National Forest, retain relatively high habitat values for anadromous *O. mykiss*. Dams, surface water diversions, and groundwater extractions have frequently disconnected the upper and lower portions of watersheds, as well as degraded instream and riparian habitats in both areas. Because the mainstem river channels are the conduits that connect upstream spawning and rearing habitats with the ocean, recovery actions in watersheds impaired in this manner focus on reducing the severity of anthropogenic impacts along the mainstems. Encroachment into riparian areas and flood control activities that degrade instream habitat or restrict fish passage should be avoided or minimized in order to promote connectivity between the ocean and upstream spawning and rearing habitats. Additionally, degraded estuarine conditions stemming from filling, artificial sandbar manipulation, and both point and non-point waste discharges are addressed by specific recovery actions for the SCCCS Recovery Planning Area.

This chapter describes DPS-wide recovery actions. DPS-wide recovery actions are recommendations that are designed to address widespread and often multiple threat sources across the SCCCS Recovery Planning Area such as the inadequate implementation and enforcement of local, state, and federal regulations. Subsequent chapters describe BPG-specific conditions, the results of threats assessments for component watersheds, and the recommended recovery actions for each component watershed.

An array of natural and anthropogenic conditions has reduced the population size and historical distribution of South-Central California Coast steelhead. Many of these causes of decline are systemic and persistent, crossing numerous environmental and political boundaries. The sources and reasons for decline are identified in Federal Register Notices and this Recovery Plan. Effectively addressing these causes of decline involves multiple challenges and opportunities that include: 1) development of new and effective implementation of current laws, policies, and regulations at the local, state, and federal levels; 2) securing adequate funding for implementation of recovery actions; 3)

developing strategic partnerships at the local, state, and federal levels; (4) assuring effective prioritization of restoration, threats abatement, and monitoring actions; and (5) conducting education and outreach. (See Appendix E, Recovery Action Cost Estimates for Steelhead Recovery Planning, for a list of federal, state, and local funding sources available to support the implementation of recovery actions.)

8.1 DPS-WIDE RECOVERY ACTIONS

DPS-wide recovery actions addressing widespread threat sources include the following:

- Collaboration between water facility owners and operators, and local, state and federal agencies to ensure releases from water storage and diversion facilities (see Table 8-2 and the BPG recovery action tables) will maintain surface flows necessary to support all *O. mykiss* life history stages, including adult and juvenile *O. mykiss* migration, spawning, incubation, and rearing habitat.
- Collaboration between riparian landowners and the State Water Resources Control Board to minimize withdrawals from riparian wells and develop rain/runoff collection facilities to serve out-of-stream water demands, and ensure adequate bypass flows necessary to support all *O. mykiss* life history stages, including adult and juvenile *O. mykiss* migration, spawning, incubation, and rearing habitat.
- Physically modify passage barriers (including the dams and diversion facilities listed in Table 8-2 and the BPG recovery action tables) to allow natural rates of migration to upstream spawning and rearing habitats.
- Finalize and implement the California Coastal Salmonid Population Monitoring Plan. Implementation of the California Coastal Monitoring Plan is essential for evaluating the long-term viability of South-Central California Coast steelhead as well as other species of listed salmonids in California.
- Prioritize restoration funds, notably the Pacific Coast Salmon Restoration Fund and California's Fisheries Restoration Grant Program (FRGP), in Core 1 and 2 watersheds.
- Implement restoration projects to provide access to historic steelhead spawning and rearing habitats and increase egg-to-smolt life stage survival.
  - Support agency actions to secure funding for, and engage in, full enforcement of relevant laws, codes, regulations and ordinances protective of steelhead and their habitats.
  - Collaboration between CalTrans, counties, and others with oversight on road practices to reduce or remove transportation related barriers to upstream and downstream passage (including railroad bridges, abutments, and similar structures identified in BPG recovery action tables).
  - Collaboration between U.S. Forest Service and the California Department of Forestry to ensure that fire-suppression and post-fire suppression activities are conducted in a manner which is protective of steelhead and steelhead habitats.
  - Enhance protection of natural in-channel and riparian habitats, including appropriate management of flood-control activities (both routine maintenance and emergency measures), off-road vehicle use, and in-river sand and gravel mining practices commensurate with habitat and life history requirements of steelhead.
  - Reduce water pollutants such as fine sediments, pesticides, herbicides, and other non-point and point source waste discharges (Total Maximum Daily Load) commensurate with habitat and life history requirements of steelhead. This

should be accomplished through public education, watershed–management and management of public and private facilities releasing waste discharges (See Appendix F, Pesticide Best Management Practices).

- Close remaining areas currently open to angling below impassible barriers in all anadromous waters; in non-anadromous waters (*i.e.*, those currently inaccessible to upstream-migrating steelhead because of anthropologic barriers) or complete a Fishery Management and Evaluation Plan for anadromous waters of the SCCCS DPS; assess impacts of angling on native *O. mykiss* above barriers which are currently impassable to upstream-migrating steelhead.
- Eliminate the stocking of hatchery-reared fish in anadromous waters; in waters where stocked fish may reach anadromous waters ensure that such fish are adequately controlled to prevent the introduction of hatchery-reared fish into anadromous waters.
- Convene a committee of agency personnel and scientists (*e.g.*, the DFG, NMFS' Fisheries Science Centers, U.S. Fish and Wildlife Service) for the purpose of establishing a pilot conservation hatchery program for threatened steelhead consistent with the principles and purposes outlined in section 8.3 below.
- Assess the condition of and restore estuarine habitats through the control of fill, waste discharges, and establishment of buffers commensurate with the habitat and life history requirements of steelhead.
- Manage the artificial breaching and/or draining of coastal estuaries consistent with habitat and life history requirements of steelhead (including rearing juveniles and migrating adults).
- Evaluate and mitigate the effects of transportation corridors and facilities on estuarine fluvial processes. When vehicular, railroad, or utility crossings over estuaries are replaced, upgraded, retrofitted, or enlarged, reduce or eliminate existing approach-fill and maximize the clear spanning of upstream active channel(s), floodways, and floodplains to accommodate natural river and estuarine fluvial processes.
- Review California Department of Forestry's rules for timber harvest activities south of San Francisco, and modify, if necessary, to ensure that such activities do not adversely affect steelhead migration, spawning and rearing.
- Conduct research on the relationship between resident and anadromous forms of *O. mykiss*, and related population dynamics (*e.g.*, distribution, abundance, residualization, dispersal, and recolonization rates.
- Provide for the permanent curation of deceased *O. mykiss* specimens for the purpose of making available specimens for examination and study by present and future scientific researchers.
- Survey and monitor the distribution and abundance of non-native species of plants and animals that degrade natural habitats or compete with native species within watersheds identified as core populations. Initiate efforts to eliminate, reduce, or control non-native and/or invasive species.
- Amend Army Corps Section 404 Clean Water Act (CWA) exemptions for farming, logging, and ranching activities; terminate Section 404(f) exemptions for discharges of dredged or fill material into U.S. waters (channelization) associated with agriculture, logging, ranching and farming; incorporate explicit steelhead

habitat requirements into CWA Section 401 water certification permits and 303(d) listings to protect all life-history stages, including adult and juvenile steelhead migration, spawning, incubation and rearing.

- Incorporate appropriate elements of the South-Central California Steelhead Recovery Plan into the state-sponsored and funded Integrated Regional Watershed Management Plans (IRWMP) being developed for major watersheds of South-Central California under the Integrated Regional Watershed Management Planning Act of 2002.
- Coordinate with the California Department of Fish and Game and the State Water Resources Control Board to ensure the effective implementation of California Fish and Game Code Sections 5935-5937 regarding the provision of fishways and fish flows associated with dams and diversions.
- Extend the California Water Code Section 1294.4 dealing with instream flows to protect instream beneficial uses, including native fishes, to South-Central California Coast watersheds.

8.2 RECOVERY ACTION NARRATIVES

Table 8-1 contains a narrative description of the types of recovery actions which are intended to address systemic threats identified throughout the watersheds within the SCCCS Recovery Planning Area, based upon the DPS threats assessments conducted by NMFS technical consultants, and the intrinsic potential analysis conducted by NMFS TRT. These narratives describe the general nature and biological objectives of the recovery actions which must be implemented in order to achieve the goals, objectives, and meet the viability criteria, that are identified in Chapter 6, Steelhead Goals, Objectives and Criteria, and implement the recovery strategy in outlined in Chapter 7, Steelhead Recovery Strategy.

The Recovery Plan applies these recovery actions to individual watersheds (and in some cases individual facilities) to the extent information is available, in the recovery action tables for each watershed within the BPG Chapters 9 through 13. However, the general language of recovery actions does not dictate a specific means of achieving the biological objectives of the recovery actions (*e.g.*, assure effective fish passage, provide ecological effective flow regime, control nonpoint sources of pollution or non-native species, or restore estuarine functions).

While SCCCS DPS threats assessments were identified at a watershed scale, and do not necessarily identify all specific threat sources in individual watersheds, many of the recovery actions call for more detailed threats assessment and analysis (*e.g.*, fish passage barrier inventories and assessments in watersheds where complete systematic barrier inventories are not available). Some recovery actions may involve the review and modification of local general plans and local coastal plans (along with other regional plans) to address activities regulated under the plans and programs to restore and protect steelhead habitats, and a means of implementing recovery actions at the local and regional level.

Implementation of the recovery actions will require site-specific investigations to determine on a case-by-case basis the appropriate design details, and where appropriate, operational criteria for individual facilities. For example, the specific means of providing fish passage at a particular site or facility (*e.g.*, culvert, diversion, or dam), or the flow regime necessary to provide passage or sustain ecological effective rearing habitats, must be based on site-specific technical investigations such as those undertaken for recovery actions that have already been or are in the process of being implemented. Similarly,

the recovery actions dealing with the control or elimination of non-native invasive species will require a watershed-wide, and in some cases, a reach-specific inventory and assessment of the species before the appropriate control measures can be identified and implemented.

Finally, recovery actions that involve development as defined by either the National Environmental Policy Act (NEPA) or the California Environmental Quality (CEQA) will require environmental review that could further refine individual recovery projects alternatives, identify mitigation measures, and/ or require project monitoring, as part of the project permitting process.

Table 8-1. Recovery Actions Glossary.

Threat Source	Recovery Action	Detailed Description
Agricultural Development	Develop, adopt, and implement agricultural land-use planning policies and standards	Develop, adopt, and implement land-use planning policies and development standards that restrict further agricultural encroachment within the active floodplain/riparian corridor to protect *all O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation, and rearing, and their associated habitats.
	Manage livestock grazing to maintain or restore aquatic habitat functions	Develop and implement plan to manage livestock grazing to restore and/or protect riparian functions (*e.g.*, control stream bank and floodplain erosion, dissipate stream energy, capture sediment during high flows, *etc.*) to sustain aquatic habitat features (*e.g.*, physical diversity, cover, and water quality) essential for all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing.
	Manage agricultural development and restore riparian zones	Develop and implement plan to manage agricultural development outside of the active floodplain (defined by 2-5 year frequency flood event) to create an effective riparian buffer; restore and re-vegetate a minimum riparian buffer to allow the channel to maintain natural structural diversity to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats. The extent of the floodplain and riparian buffer shall be determined on a case-by-case basis taking into account site specific conditions.
Agricultural Effluents	Develop and implement plan to minimize runoff from agricultural activities	Develop and implement plan to reduce or eliminate nutrient and pesticide/herbicide runoff and sediment inputs into natural watercourses from agricultural activities to provide water quality suitable for all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitat.
Culverts and Road Crossings (Passage Barriers)	Develop and implement plan to remove or modify fish passage barriers within the watershed	Develop and implement plan to prioritize, remove and/or modify anthropogenic fish passage barriers within the watershed to allow natural rates of adult and juvenile *O. mykiss* migration between the estuary and upstream spawning and rearing habitats, passage of smolts and kelts downstream to the estuary and the ocean, and to reduce intrusion into the riparian corridor and restore sediment transport.
	Conduct watershed-wide fish passage barrier assessment	Conduct watershed-wide fish passage barrier assessment between the ocean and all upstream spawning and rearing areas (including above existing barriers). This passage barrier assessment should utilize the protocols identified in the California Department of Fish and Game's California Salmonid Stream Habitat Restoration Manual (Flosi *et al*. 2010, or the most current version).
Dams and Surface Water Diversions	Develop and implement water management plan for diversion operations	Develop and implement a water management plan to identify the appropriate diversion rates for all surface water diversions that will maintain surface flows necessary to support all *O. mykiss* life history stages, including adult and juvenile *O. mykiss* migration, and suitable spawning, incubation, and rearing habitat.
	Develop and implement water management plan for dam operations	Develop and implement operational plan to provide seasonal releases from dams to provide surface flows necessary to support all *O. mykiss* life history stages, including adult and juvenile *O. mykiss* migration, spawning, incubation, and rearing habitats.

Threat Source	Recovery Action	Detailed Description
	Provide fish passage around dams and diversions	Develop and implement plan to physically modify or remove fish passage barriers at dams, debris basins or diversions to allow natural rates of adult and juvenile *O. mykiss* migration between the estuary and upstream spawning and rearing habitats, and passage of smolts and kelts downstream to the estuary and ocean.
Flood Control Maintenance	Develop and implement flood control maintenance program	Develop and implement flood control maintenance plan to minimize the frequency and intensity of disturbance of instream habitats and riparian vegetation (*e.g.*, modification of natural channel morphology and removal of native vegetation) of the mainstem and tributaries to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
Groundwater Extraction	Conduct groundwater extraction analysis and assessment	Conduct hydrological analysis to identify groundwater extraction rates, effects on the natural pattern (timing, duration and magnitude) of surface flows in the mainstem, tributaries, and the estuary, and effects on all *O. mykiss* life history stages, including adult and juvenile *O. mykiss* migration, spawning, incubation and rearing habitats.
	Develop and implement groundwater monitoring and management program	Develop and implement groundwater monitoring program to guide management of groundwater extractions to ensure surface flows provide essential support for all *O. mykiss* life history stages, including adult and juvenile *O. mykiss* migration, spawning, incubation and rearing habitats.
Levees and Channelization	Develop and implement plan to restore natural channel features	Develop and implement plan to modify channelized or artificially stabilized portions of the mainstem and tributaries, wherever feasible, to restore natural channel features and habitat functions, including natural channel bottom morphology and riparian vegetation, to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	Develop and implement plan to vegetate levees with native, naturally occurring vegetation, wherever feasible, and eliminate or minimize the use of herbicides to control native vegetation adjacent to existing levees to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Develop and implement stream bank and riparian corridor restoration plan	Develop and implement stream bank and riparian corridor restoration plan to reduce channel incision, sedimentation from bank erosion, and reduce or eliminate the need for artificial bank stabilization; wherever feasible, remove rip-rap and other artificial bank stabilization features on mainstem and tributaries and replace with bio-engineered bank stabilization, or an additional set-back, to allow the channel to maintain natural structural diversity to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
Mining and Quarrying	Review and modify mining operations	Review aggregate and hard rock mining operations (past, current and future) for conformance with the National Marine Fisheries Services Guidelines for Removal of Sediment from Freshwater Salmonid Habitat (Cluer 2004). Modify current and future mining operations, where necessary to comply with the relevant provisions of the guidelines, and remediate past (including terminated operations to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.

Threat Source	Recovery Action	Detailed Description
	Develop and implement plan to remove quarry and landslide debris from the channel	Develop and implement plan to remove quarry and landside debris from the channel, maintain the channel free from such debris, and establish a riparian buffer with native, locally occurring species to protect all *O. mykiss* life history stages, including adult and juvenile *O. mykiss* migration, and spawning and rearing habitats.
Non-Native Species	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	Develop and implement watershed-wide plan to identify and determine the type, distribution and density of non-native species; assess their impacts on all *O. mykiss* life history stages; and eliminate or control non-native species of plants and animals (particularly fish and amphibians); restore riparian and upland areas with native, locally occurring plant species to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Develop and implement non-native species monitoring program	Develop and implement on-going monitoring program to track the status and impacts of non-native species of plants and animals on all *O. mykiss* life history stages, particularly rearing juveniles.
	Develop and implement public education program on non-native species impacts	Develop and implement public education program (including signage at public access points) to inform the general public of the adverse effects of introducing non-native species into natural ecosystems.
Recreational Facilities	Manage off-road recreational vehicle activity in riparian floodplain corridors	Develop, adopt, and implement land-use policies and standards to manage off-road vehicular activity within the riparian/floodplain corridor of the mainstem and tributaries to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Review and modify development and management plans for recreational areas and national forests	Review development and management plans for recreational areas and national forest lands and modify to provide specific provisions to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats. Provide specific provisions for the restoration and protection of creeks, rivers, estuaries, wetlands and riparian/floodplain areas, including an effective setback for all development from estuarine and riparian habitats. Regulate the use of day-use areas and other recreational facilities to minimize impacts to aquatic and wetland habitats to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Develop and implement public education program on watershed processes	Develop and implement public education program (including signage at public access points) to promote public understanding of watershed processes (including the natural fire-cycle) and *O. mykiss* ecology to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
Roads	Manage roadways and adjacent riparian corridor and restore abandoned roadways	Develop and implement plan to manage roadways adjacent to riparian/floodplain corridors to reduce sedimentation, or other non-point pollution sources, before it enters natural watercourses to protect all steelhead life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats. Restore and re-vegetate abandoned roadways with native, locally occurring species.

Threat Source	Recovery Action	Detailed Description
	Retrofit storm drains to filter runoff from roadways	Develop and implement plan to retrofit storm drains to filter runoff from roadways to remove sediments and other non-point pollutants before it enters natural watercourses to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads and maximize the clear spanning of active channels, floodways, and estuaries to accommodate natural river and estuarine fluvial processes to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
Upslope/Upstream Activities	Develop and implement an estuary restoration and management plan	Develop and implement restoration and management plan for the relevant estuary. To the maximum extent feasible, the plan should include restoring the physical configuration, size and diversity of the wetland habitats, eliminating exotic species, controlling artificial breaching of the sand bar, and establishing an effective buffer to restore estuarine functions and promote *O. mykiss* use (including rearing and acclimation) of the estuary.
	Review and modify applicable County and/or City Local Coastal Plans	Review applicable County and/or City Local Coastal Plans and modify to provide specific provisions for the protection of all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Review applicable Integrated Natural Resources Management Plans	Review the relevant Integrated Natural Resources Management Plan (INRMP) and modify to provide specific provisions for the protection and restoration of all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation, and rearing habitats.
Urban Development	Develop, adopt, and implement urban land-use planning policies and standards	Develop, adopt and implement land-use planning policies and development standards that restrict further development in the floodplain/riparian corridor to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing, habitats.
	Retrofit storm drains in developed areas	Develop and implement plan to retrofit storm drains in urban areas to control sediments and other non-point pollutants in runoff from impervious surfaces before it enters natural watercourses to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	Develop and implement riparian restoration plan throughout the mainstem and tributaries to replace artificial bank stabilization, structures wherever feasible, and provide an effective riparian buffer on either side of mainstem and tributaries, utilizing native, locally occurring species, to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
Urban Effluents	Review California Regional Water Quality Control Boards Watershed Plans and modify Stormwater Permits	Review California Regional Water Quality Control Boards Regional Plans, and Stormwater Permits, and modify to include specific provisions for the protection of all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.

Threat Source	Recovery Action	Detailed Description
	Review, assess and modify NPDES wastewater discharge permits	Review and assess National Pollution Elimination Discharge System (NPDES) wastewater discharge permits to determine effects of discharge on adult and juvenile *O. mykiss* life stages, including migration, spawning, and rearing habits. Modify discharge requirements, where necessary, to ensure discharge is adequate to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
	Review, assess and modify residential and commercial wastewater septic treatment facilities	Review and assess residential and commercial wastewater septic treatment facilities to determine effects of discharge on all *O. mykiss* life stages, including migration, spawning, and rearing habits. Modify septic systems, where necessary, to ensure discharge is adequate to protect all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.
Wildfires	Develop and implement an integrated wildland fire and hazardous fuels management plan	Develop and implement an integrated wildland fire and hazardous fuels management plan, including monitoring, remediation and adaptive management, to reduce potentially catastrophic wildland fire effects to steelhead and their habitat and preserve natural ecosystem processes (including sediment transport and deposition).

8.3 CONSERVATION HATCHERIES

One potential recovery strategy involves the use of conservation hatcheries to preserve imminently threatened populations, or to accelerate restoration of steelhead runs by temporarily supplementing natural production (California Department of Fish and Game and U.S. Fish and Wildlife Service 2010, California Department of Fish and Game 2004, California Department of Fish and Game and National Marine Fisheries Service 2001). While a conservation hatchery program[1] can complement the overall recovery effort, the role of such a program cannot be reasonably expected to substitute for the extensive restoration of habitat function, value, and connectivity that is required to abate threats to South-Central California Coast steelhead.

Conservation hatcheries can be used for a number of recovery related purposes, including: 1) providing a means to preserve local populations faced with immediate extirpation as a result of catastrophic events such as wildfires, toxic spills, dewatering of watercourses, *etc.*; 2) preserving the remaining genotypic and phenotypic characteristics that promote life history variability through captive broodstock, supplementation, and gene-bank programs to reduce short-term risk of extinction; 3) reintroduction of populations in restored watersheds; and 4) conducting research on South-Central California Coast stocks relevant to the conservation of the species. (See the discussion of research issues in Chapter 13, South-Central California Steelhead Research, Monitoring and Adaptive Management.)

Issues that should be considered prior to implementing a conservation hatchery program include: 1) conditions under which rescue, reestablishment or supplementation could be used in wild steelhead recovery; 2) methods for rescue, re-establishment or supplementation, and; 3) protocols for evaluating the effectiveness of such conservation hatchery functions over time. Conservation programs must be guided by scientific research and management strategies to meet program objectives recovering threatened or endangered populations (Flagg and Nash 1999).

Genetic resources that represent the ecological and genetic diversity of the species can reside in hatchery fish as well as in wild fish (Waples 2010). As a consequence, NMFS has extended protection under the Endangered Species Act (ESA) to certain hatchery fish programs which preserve the genetic legacy of the listed species and are managed as refugia populations (70 FR 37204, June 28, 2005).

8.3.1 Recovery Role of Conservation Hatcheries

The principal strategy of salmonid conservation and recovery is the protection and restoration of healthy ecosystems upon which they naturally rely, consistent with the ESA's stated purpose to conserve "the ecosystems upon which endangered and threatened species depend" (ESA section 2(b)). However, a natural recovery of local extinctions depends on one or more recolonization events, a process that operates on an indefinite timescale. Likewise, the viability of a depressed population, characterized by small size, fragmented structure, and impacted genetics (*e.g.*, bottlenecks, inbreeding, outbreeding depression, *etc.*), may be so compromised that its response to restored or increased availability of habitat is not sufficient to prevent imminent extinction (Araki *et al. 2009, 2008,* 2007a 2007b, Berejikian *et al*. 2011, 2009, 2008, 2005, Kuligowski *et al*. 2005, Hayes *et al.* 2004). Either case may require management intervention to attain self-sufficiency and sustainability in the wild.

There is considerable uncertainty regarding the ability of artificial propagation to increase

[1] A conservation hatchery is a program that conserves and propagates steelhead taken from the wild for conservation purposes, and returns the progeny to their native habitats to mature and reproduce naturally.

population abundance over the long-term, and it cannot be assumed that artificial augmentation will reduce extinction risk. The artificial advantage given to hatchery fish during early life stages can result in a higher rate of return over that of natural fish escapement, and result in increasing hatchery fish representation in the natural population over time. There is a risk to natural recovery from increasing dependency on fish augmentation. Conservation hatcheries must therefore monitor the effects of the program on the natural population using criteria which would trigger modification to or cessation of the conservation program (Chilcote 2011, Paquet *et al*. 2011, Tatara *et al*. 2011a, 2011b, Fraser 2008, Myers *et al.* 2004, Ford 2002).

Conservation hatchery programs employing best management practices can reduce the likelihood of extinction by contributing to one or more of the viable salmonid population (VSP) parameters at the population and evolutionarily significant unit (ESU) or distinct population segment (DPS) levels (McElhany *et al*. 2000):

Abundance. Conservation hatchery fish may reduce extinction risk by increasing the total abundance of fish in a population in the short term, providing sufficient numbers to dampen deterministic density effects, environmental variation, genetic processes, demographic stochasticity, ecological feedback, and catastrophes.

Growth Rate. Conservation hatchery fish potentially increase the total abundance of successful natural spawners, thereby increasing productivity in the collective contribution of natural-origin and hatchery-origin spawners to productivity in the natural environment.

Spatial Structure. Small populations are at risk of local and regional extinctions because of ongoing habitat loss and fragmentation, as well as dysfunctional expression of species behavior undermining its sustainability. The introduction of conservation hatchery fish into suitable unoccupied habitat or for supplementing sparsely populated habitat concomitant with restoration projects that increase interconnected natural habitat may reestablish natural spatial population structure.

Diversity. To conserve the adaptive diversity of salmonid populations, the environment in which they co-evolved and the natural processes which select for population fitness should be allowed to continue without human impact or influence. Conservation hatcheries can conserve valuable genes and genotypes, and are managed to minimize ecological and domestication effects on natural populations, conserve and maximize genetic variability and life history diversity within and among stocks.

A conservation hatchery would provide an appropriate platform for undertaking appropriate research of the topics outlined above and could provide effective guidance in the use of a conservation hatchery program to protect the currently depressed steelhead stocks and recover the threatened steelhead populations of the SCCCS Recovery Planning Area.

8.3.2 Basic Elements of a Conservation Hatchery Program

A conservation hatchery program must be:

1) Guided by a Hatchery and Genetic Management Plan, based on the best available scientific knowledge, and/or testable assumptions where information is lacking;

2) Consistent with the overall strategy, goals, objectives, and specific provisions of the Recovery Plan;

3) Based on an adaptive management, iterative process aimed at reducing uncertainty through monitoring and re-evaluation;

4) Supported by a monitoring component to:

a) Evaluate the short- and long-term goals and objectives of the program
b) Determine if and when management protocols need to be revised
c) Determine when the program should adapt to evolving recovery needs
d) Determine when the conservation hatchery program is no longer needed.
e)

5) Supported by a research program to investigate issues such as:
:

f) Fish culture problems that arise within the program
g) Fish response to habitat, environmental challenges, pathogens, *etc*.
h) Factors which contribute to reduced fitness and reproductive success of hatchery fish in the natural environment
i) Behavioral changes of conservation hatchery reared fish released into their natal waters that may lead to changes in the expression of different life history strategies (*e.g.*, anadromous or freshwater resident forms).

6) Contains criteria and a strategy for terminating the conservation hatchery program and re-directing resources to the rehabilitation of watershed processes and sustainable management of fish habitat.

8.3.3 Considerations for Establishing a Conservation Hatchery Program

An important consideration within the overall planning for recovery of threatened steelhead involves knowing when to start a conservation hatchery program (Flagg and Nash 1999).

The appropriate use for a conservation hatchery should be guided by several considerations: 1) the biological significance of the population; 2) genetic diversity; 3) population viability; and 4) the potential loss of populations exhibiting any of the first three characteristics. Each of these is described below.

Biological Significance of the South-Central Coast Steelhead populations. The biological significance of a population is expressed in the innate genetic and phenotypic characteristics, and other novel biological and ecological attributes, particularly those attributes that are not observed in other conspecific populations. With regard to the threatened SCCCS DPS, the characterization of the historical steelhead population developed by the TRT provides evidence that certain watershed-specific populations possess a high likelihood of producing steelhead with genetic and phenotypic characteristics that favor survival in a spatially and temporally highly-variable environment. Because many of the inland populations (*e.g.*, Salinas, Arroyo Seco, Upper Salinas, Pajaro, Carmel, Arroyo Grande) extend over a broad and geographically diverse area, these populations are able to withstand environmental stochasticity and possess ecologically significant attributes likely not found in most other populations.

Genetic Diversity. The amount of genetic diversity among individuals provides the foundation for a population to adapt to fluctuating environmental conditions, and contributes to its continued evolvability in response to longer-term changes such as projected climate changes. Generally, high genetic diversity favors growth and survival of individual populations. Genetic diversity of a population can be estimated quantitatively based on parameters, such as effective population size (N_e). The abundance of a population that falls below a specified N_e may be at risk of losing the necessary amount of genetic diversity that should be maintained over time, which does not favor survival in a stochastic environment. General guidelines or numerical values for N_e are specified in the literature for

maintaining minimum N_e for individual populations, but may require further research specifically for populations of South-Central California Coast steelhead.

Population Viability. Whether a population is likely to be viable is another key considering in determining the proper timing of a conservation hatchery. In particular, information about population size, population growth rate, spatial structure, and diversity provide an indication of the sort of extinction risk a species faces. Generally, small populations have a higher risk of extinction than larger populations. With regard to the threatened SCCCS DPS, evidence indicates the populations are at high risk of extinction and are not currently viable.

Potential Population Loss. Finally, a population exhibiting any of the characteristics noted above that is threatened with imminent extirpation as a result of anthropogenic activities, natural catastrophic events such as wildfire or massive sedimentation, or a combination of the two, may be preserved by the temporary placement of representatives of such a population in a conservation hatchery, or other secure location.

8.4 ESTIMATED TIME TO RECOVERY AND DELISTING

NMFS's interim recovery planning guidance (2010a) provides that Recovery Plans "indicate the anticipated year that recovery would be achieved. Estimates should be carried through to the date of full recovery, *i.e.*, when recovery criteria could be met. There may be extreme cases in which estimating a date and cost to recovery is not possible due to uncertainty in what actions will need to be taken to recover the species." In those circumstances "an order of magnitude for cost and some indication of time in terms of decades, should be provided if at all possible."

Estimates of the time to recovery entails three basic elements: time to complete all major recovery actions + time for habitat to respond + time for the listed species to respond to recovery actions:

Regarding the time to complete all major recovery actions, this component should reflect:

The longest time any recovery action would take to complete, assuming that all recovery actions began more or less immediately (or within 10 years) of completion of the Recovery Plan.

Sufficient funding to complete recovery actions.

Regarding the time for habitat to respond to recovery actions, this component should reflect:

The longest time the habitat recovery would take.

The variation in the extent of needed habitat restoration (extremely degraded habitat could have longer restoration estimates).

Regarding the time for the species to respond to recovery actions, this component should reflect:

The number of generations for which demographic targets must be met in order to delist.

Or for South-Central California Coast steelhead. the length of a complete ocean multi-decadal cycle, or 60 years).

The precision of any estimate of time to recover and delist a species is necessarily governed by the specificity with which any of these components can be estimated.

Completion of a majority of the recovery actions is estimated to vary from 5 to 10 years, though some of the larger, more complicated recovery actions such as the physical or operational modification of larger dams may take several

decades. The recovery of habitat could vary depending on the type of habitat (e.g., migration, freshwater spawning and rearing, or estuarine habitat), with some migration and estuarine habitats taking less time, and some spawning and rearing habitats taking more time to respond to recovery actions. As with the completion of recovery actions, it is estimated that these time frames would vary in a majority of cases to from 5 to 10 years, though the response of some habitats may taking longer, depending of rainfall and runoff patterns. The time for the species to respond to recovery actions is the most challenging time component to estimate for a variety of reasons: these include the dependency of anadromous runs and spawning and rearing success upon rainfall and runoff patterns, which can be cyclic, and may also be significantly influenced by projected climate changes, and uncertainties regarding aspects of the demographics of South-Central California Coast steelhead (*e.g.*, rate of dispersal between populations, rate of switching between resident and anadromous life cycle strategies).

Given the above estimates, and the need to meet the DPS recovery run size criterion during poor ocean conditions (measured over a multi-decadal cycle of 60 years), the time to recovery can be provisionally estimated to vary from 80 to 100 years. A modification of the provisional population or SCCCS DPS viability criteria resulting in smaller run-sizes, or the number or distribution of recovered populations could shorten the time to recovery. Delays in the completion of recovery actions, time for habitats to respond to recovery actions, or the species' to respond to recovery actions would extend the time to recovery.

9. Interior Coast Range Biogeographic Population Group

"Assessment at the group level indicates a priority for securing inland populations in southern Coast Ranges and Transverse Ranges, and a need to maintain not just the fluvial-anadromous life-history form, but also lagoon-anadromous and freshwater-resident forms in each population."

NOAA Fisheries Technical Recovery Team
Viability Criteria for South-Central and Southern California, 2007

9.1 LOCATION AND PHYSICAL CHARACTERISTICS

The Interior Coast Range BPG region is the largest of the four BPG regions in SCCCS Recovery Planning Area and includes the east-facing (interior) slopes of the Central Coast Ranges (Santa Lucia Mountains)and Santa Cruz Mountains and the west-facing slopes of the Inner Coast Range (Diablo, Gabilan, Caliente, and Temblor ranges) (Figure 9-1). This region extends 180 miles across the entire length of (north-to-south) the SCCCS Recovery Planning Area and includes portions of Santa Clara, San Benito, Monterey, and San Luis Obispo counties. This BPG region consists of two major watersheds, the Pajaro River and Salinas River, which flow into the Pacific Ocean at Monterey Bay. The Pajaro River watershed includes the Uvas Creek sub-watershed. The Salinas River watershed is the largest coastal watershed south of San Francisco, covering over 2.8 million acres (4,426 square miles) and contains two major sub-basins: the Lower Salinas sub-basin, which includes the Gabilan Creek and

Arroyo Seco watersheds, and the Upper Salinas sub-basin, which includes the San Antonio River and Nacimiento River watersheds (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

Pajaro River

Tectonic activity associated with the northwest-trending San Andreas Fault has created a parallel series of northwest-

southeast trending basins and ranges in this part of California. The mainstem of the Salinas River runs through the center of most of this BPG region and two major tributaries, the San Antonio and Nacimiento rivers are unusual in that they flow southward for most of their length before their confluence with the Salinas River, which flows northwest (Figure 9-1).

Salinas River

San Antonio River

Average annual precipitation in this region is relatively low and shows high spatial variability. In general, the higher elevations get more moisture, but because of the "rain shadow" effect created by the coastal slope of the Central Coast Range, the eastern half of the Interior Coast Range BPG receives significantly less precipitation than the western half. The upper reaches of the Pajaro River watershed extend into the redwood coniferous forests of the Santa Cruz Mountains and receive significantly more rainfall than do other portions of the Interior Coast Range BPG.

Uvas Creek – Pajaro River Tributary

Although the highly dissected terrain contributes to a very large total stream length in this region (7,773 miles), the majority of drainages exhibit seasonal surface flow or have extensive seasonal reaches because of highly variable patterns of precipitation (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

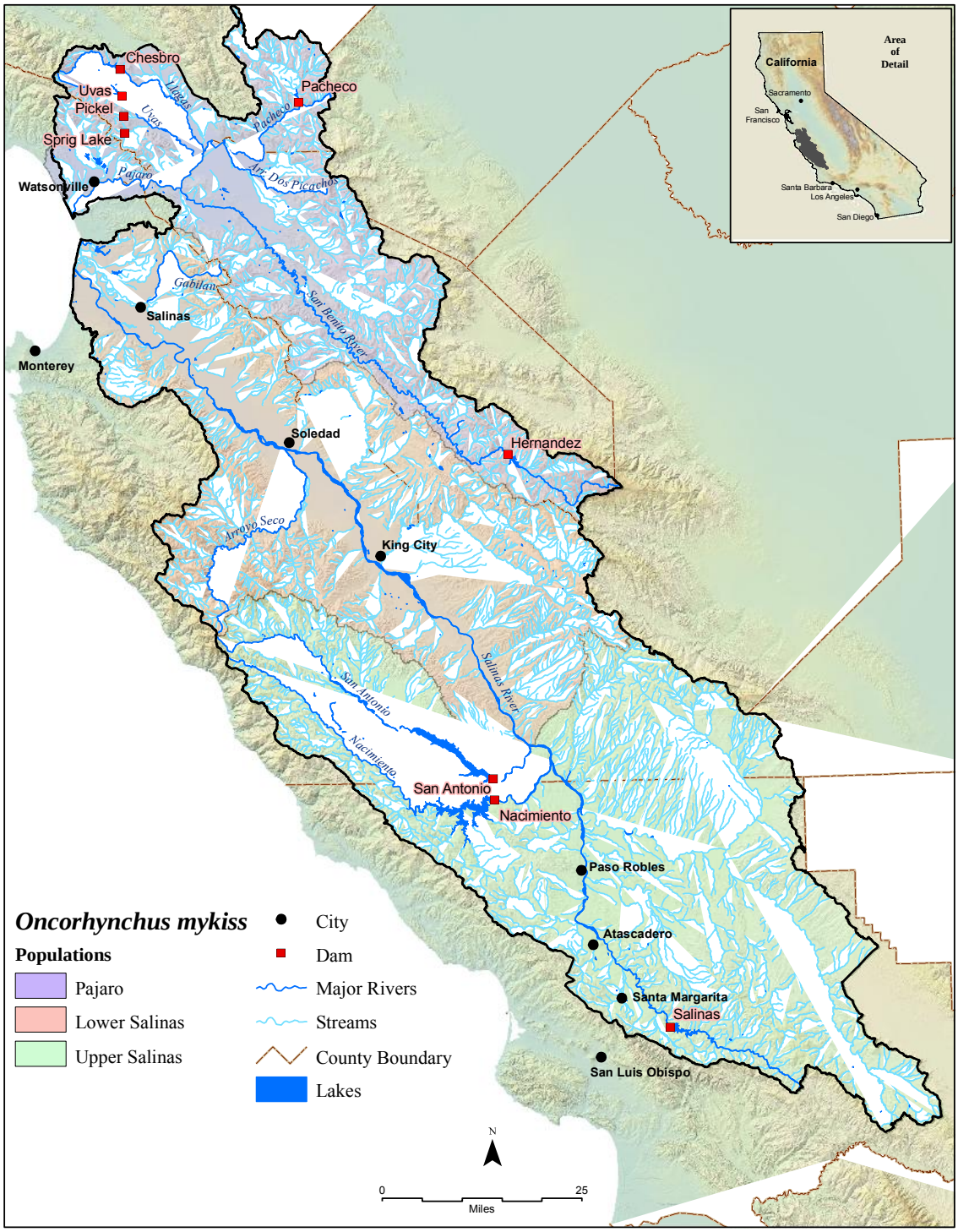


Figure 9-1. The Interior Coast Range BGP region. Seven populations/watersheds were analyzed in this region: two in the Pajaro River watershed (mainstem Pajaro River and Uvas Creek); three in the Lower Salinas River watershed (mainstem Salinas, Gabilan Creek, Arroyo Seco), and two in the Upper Salinas River watershed (San Antonio River and Nacimiento River, including the Salinas mainstem).

9.2 LAND USE

Table 9-1 summarizes land use and population density in the Interior Coast Range BPG region. Although human population density is relatively low for the region as a whole (averaging about 100 persons/square mile), population centers such as Atascadero, Paso Robles, and Salinas are growing rapidly and are surrounded by large tracts of semi-developed rural land. Most of the land in the Pajaro River watershed, along the mainstem of the Salinas River (*i.e.,* the Salinas Valley), and throughout the eastern half of the BPG region, is privately owned. Public ownership of land is concentrated in the Los Padres National Forest and military reservations, such as Fort Hunter-Liggett and Camp Roberts, located in the western portions of this BPG region. Additionally, several rivers have been evaluated for consideration as federally-designated Wild and Scenic Rivers, including Arroyo Seco and Tassajara Creek (tributaries to the Salinas River within the Los Padres National Forest).

Arroyo Seco –Salinas River Tributary

Agriculture (row crop orchard cultivation, livestock ranching and increasingly vineyards within the Salinas River watershed), are important land uses that directly or indirectly affect watershed processes throughout this BPG region. A major consequence of agricultural activity in this region is reservoir development (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b; see also, Central Coast Salmon Enhancement 2008, Grossinger *et al.* 2008, U.S. Army 2007, Harris *et al.* 2006, Upper Salinas-Las Tablas Resource Conservation District 2004, Newman et al. 2003, Watson *et al*. 2000, California Regional Water Quality Control Board 1999, Stephenson and Calcarone 1999, California Department of Water Resources 1978).

Agriculture – Confluence of Arroyo Seco and Salinas River

There are at least 37 dams in this region that are large enough to be regulated by the California Department of Water Resources and/or Department of Defense (Figure 9-1 shows nine of the most significant dams). These dams are owned and operated by federal, state, public utility, local government, or private interests for irrigation, flood control and storm water management, recreation, municipal water supply, hydroelectric power generation, fire protection, farm ponds, or a combination of these purposes (California Department of Fish and Game 2011b, California Department of Water Resources 1988).

San Antonio Dam

The largest reservoirs in this region, San Antonio Lake (on the San Antonio River), Lake Nacimiento (on the Nacimiento River), and Santa Margarita Lake (on the Upper Salinas River mainstem), receive extensive recreational use. The larger dams such as Uvas, San Antonio, Nacimiento, and Salinas are do not provide upstream fish passage, though may inadvertently allow downstream fish migration from areas above the reservoirs. Several of the smaller dams such as Sprig and Pickle have been modified to allow fish passage: in the case of Sprig Dam, it is no longer in operation and has been permanently drained, with an open portal at its base; Pickel Dam has an open port at its base as well as a fish ladder.

Rock Quarry Operation – Salinas River

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Instream gravel mining operations are also significant land uses in both the Pajaro and Salinas River watershed (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

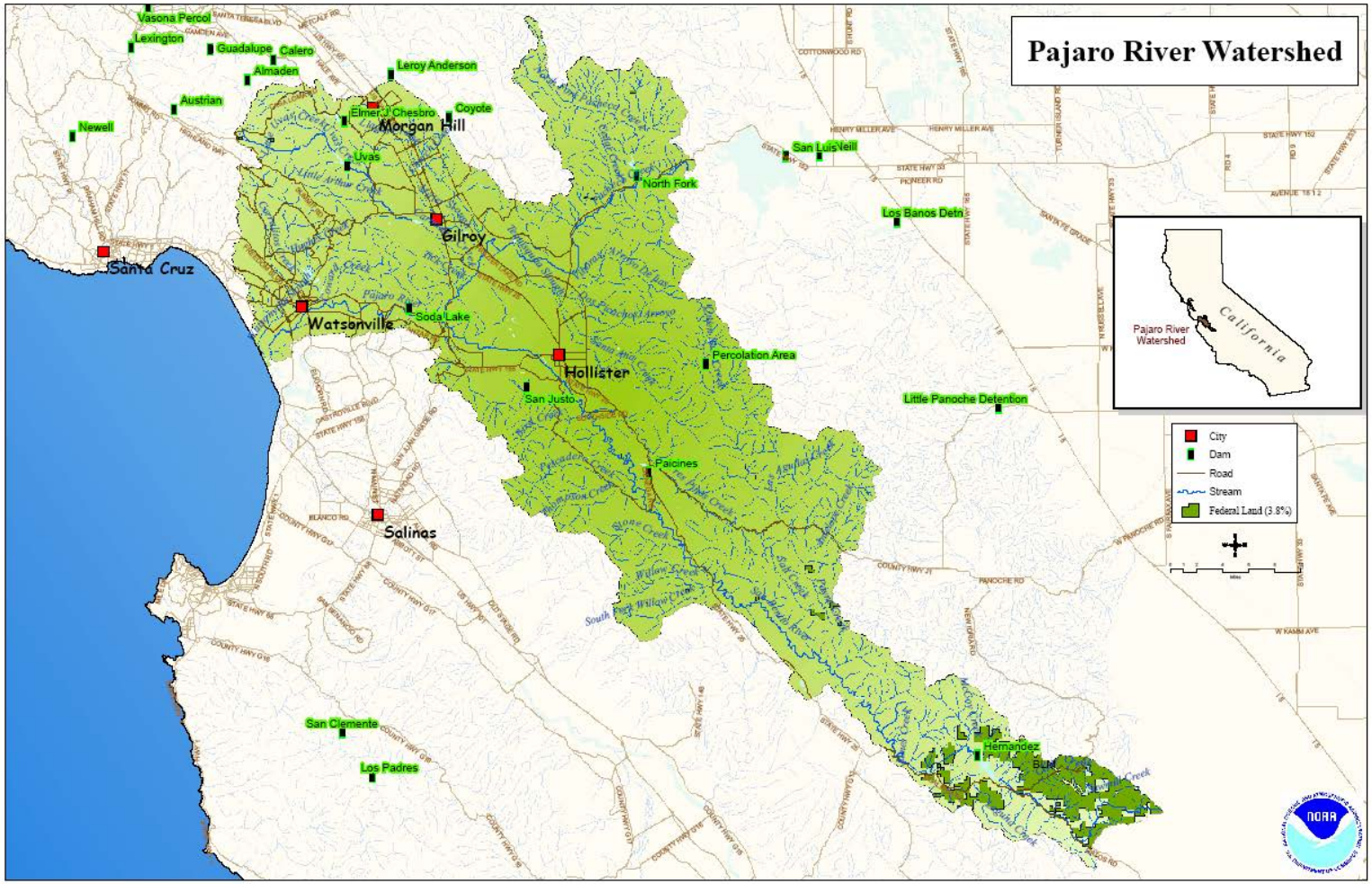

Figure 9-2. Federal and Non-Federal Land Ownership within the Pajaro River Watershed.

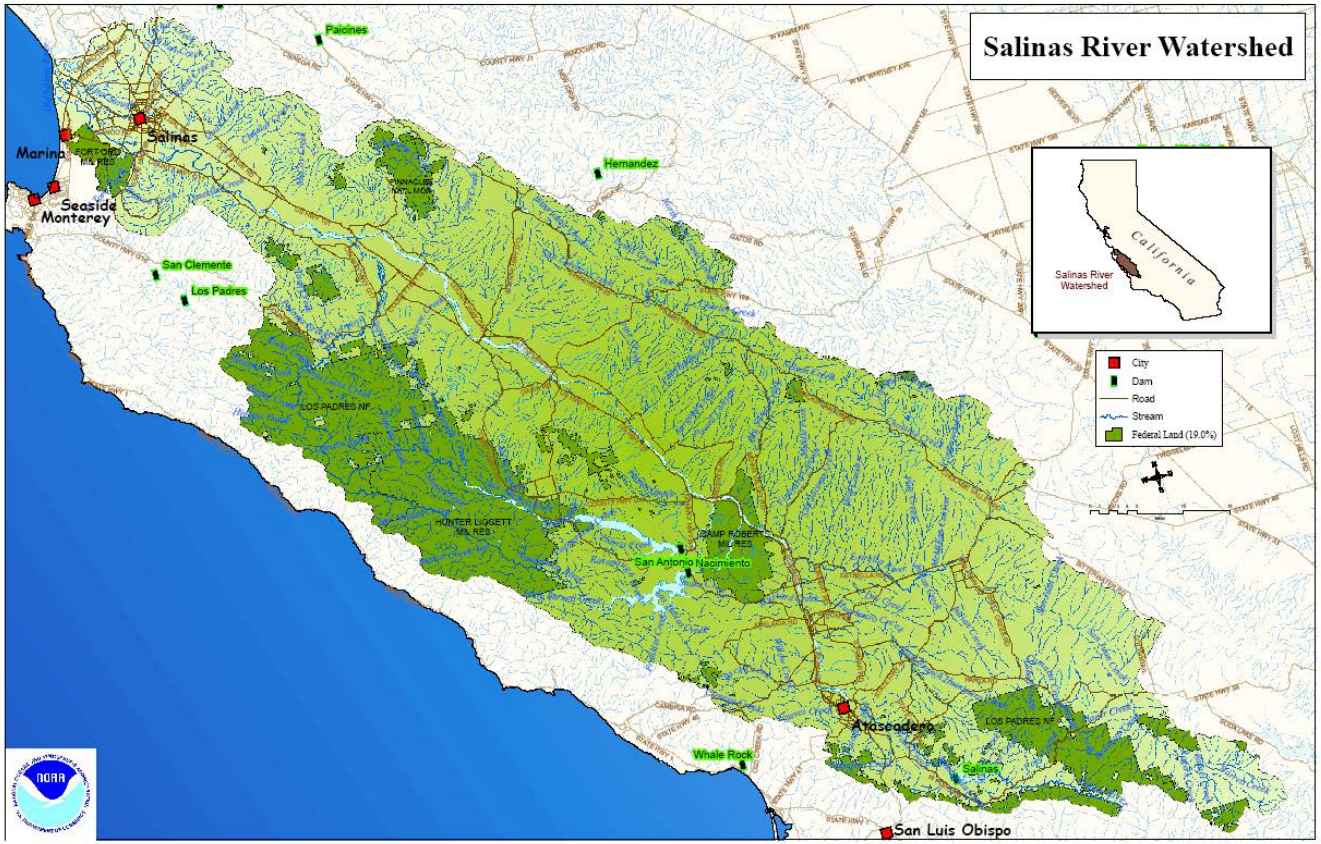

Figure 9-3. Federal and Non-Federal Land Ownership within the Salinas River Watershed.

9.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for the mainstems of the two major rivers and for five sub-watersheds in the Interior Coast Range BPG region. The mainstem and major tributaries of most of the drainages in this BPG region offer fair to poor habitat conditions for anadromous *O. mykiss*. Habitat conditions were rated as "Fair" in the Uvas Creek, Gabilan Creek, Arroyo Seco, and Nacimiento River watersheds, and "Poor" in the Pajaro River, Salinas River, and San Antonio River watersheds (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b; see also, Casagrande 2011, 2010, 2003, 2001, Casagrande and Watson 2006, Casagrande and Hagar 2003, Central Coast Salmon Enhancement 2008, Upper Salinas-Las Tablas Resource Conservation District 2004, Harris *et al*. 2006, Hagar Environmental Science 2001, Hager 2001, Stephenson and Calcarone 1999, Harvey & Stanley Associates 1983, Londquist 2001, Santa Clara Valley Water District 2006, San Benito County Water District 2006, Smith 2007a, Unites States Army 2007). Habitat quality in Uvas Creek generally improves downstream, with lower turbidity, improved substrate quality, and invertebrate production associated with winter flows contributed by downstream unregulated tributaries and the distance from Uvas Dam (Casagrande 2010a). However, the Gabilan Creek watershed is adversely impacted with fine sediment and water diversions, and upstream passage is restricted by downstream fish passage barriers (Casagrande 2010a, 2020b).

Pajaro River Valley- Agricultural Development

Each of the watersheds included in this BPG are subject to one or more instream, riparian, or upland land use conditions that pose significant threats to steelhead. In general, habitat quality declines in a downstream direction through each of these watersheds. The upper watersheds tend to be in relatively good condition, and the mainstems tend to be in fair to very poor condition. The major concern in this BPG region is that the mainstems of the two primary drainages, the Pajaro and Salinas rivers, are severely impaired by intensive anthropogenic activities related to agriculture, recreation, and residential development and associated water development and management (see discussion below). The mainstems of these rivers provide the conduits that connect the ocean, estuary, and upper watershed habitats needed by anadromous *O. mykiss* to complete their life-cycle.

Salinas River Valley – Residential Development

In other instances, major tributary watersheds, such as Arroyo Seco provide excellent spawning and rearing habitat for steelhead, though sections have ephemeral flows, particularly in the lower reaches affected by irrigation for agricultural development. Additionally, portions of the upper reaches of the San Antonio and Nacimiento rivers, provide generally seasonal habitat for salmonids, but receive low ratings because they are highly constrained by passage barriers along their lower reaches including dams and/or seasonally dry reaches (*e.g.*, in the Salinas River). Dams and dam operations, particularly in the upper tributaries to the Pajaro and Salinas River systems have had a number of significant adverse effects on hydrologic processes which are essential to creating and maintaining suitable steelhead habitats. These facilities have altered the timing, duration and magnitude of flows which are not only essential to provide migration opportunities for both adult and juvenile steelhead between the ocean and upstream spawning and rearing habitats, but also in providing appropriate sized sediment necessary for spawning and maintaining ecologically functioning riparian habitats.

Agricultural activities (including agricultural effluents) have also significantly impacted steelhead habitats through encroachment into the riparian corridor which has reduced channel complexity, reduced groundwater level through extensive water extraction for irrigation, and degraded water quality through the elevation of fine sediments and the application of agricultural pesticides and fertilizers. Instream mining operations have also degraded habitats in the Salinas River. Instream gravel mining operations in both the Pajaro and Salinas River watersheds have also contributed to degraded habitat conditions, particularly mainstem habitats.

Pajaro River Estuary

Estuarine habitat loss is also a significant threat source to anadromous *O. mykiss* populations in the Interior Coast Range BPG. Despite the large geographic size of this BPG region, its major watersheds share a single estuarine complex that has been substantially altered and reduced by a variety of agricultural and urban developments. Today, the mouths of the Pajaro River and the Salinas River at the Pacific Ocean are separated from each other by less than 10 miles. Historically, the lower reaches of these drainages meandered across a broad coastal plain to create a single estuarine complex that extended from Watsonville in the north to Marina in the south. Less than 50% of the Pajaro River estuary remains extant and the Salinas River estuary has been reduced in size by over 91%. Estuaries provide favorable rearing habitats for juvenile O. mykiss, and have been show in some cases to provide a disproportionate number of the returning anadromous adult O. mykiss in some systems (Hayes et al. 2008, Bond 2006). Such severe

losses affect anadromous *O. mykiss* populations in widely separated tributaries of the Salinas River, such as Arroyo Seco and the San Antonio and Nacimiento Rivers (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Hagar 2005a, 2005b, Casagrande 2003, Gilchrist 1997).

Salinas River Estuary – Old Salinas River Channel

Fire frequency in the Interior Coast Range BPG region is relatively low compared to other BPGs (*e.g.,* the Big Sur Coast BPG to the south). Wildland fires are not a currently a significant threat source for anadromous *O. mykiss* in the Pajaro River, Gabilan Creek, and lower Salinas River watersheds. However, the Summit Fire in 2008 within the Pajaro watershed did burn a significant portion of the Corralitos, Browns Valley, and the upper Uvas Creek sub-watersheds within the Pajaro River system. Additionally, wildfires pose a moderate to severe threat in the Arroyo Seco and upper Salinas River drainages, where 15 percent and 27 percent of the watershed has burned within the past 25 years, respectively. Increased road density allows greater access to many parts of these watersheds, and increased population density in fire-prone areas has increased fire frequency. Increased fire frequency can increase slope erosion and sediment deposition into streams, resulting in long-term changes to substrate composition and embeddedness, water quality (*e.g.,* turbidity), and water temperature (loss of riparian canopy cover).

Despite widespread and varied habitat degradation to the coastal and middle mainstems of all these watersheds, native non-anadromous *O. mykiss* populations still inhabit the relatively high-quality habitats that persist upstream of the dams in this region, and small numbers of anadromous *O. mykiss* attempt to enter and spawn in each of the watersheds of the Interior Coast Range BPG when flow conditions are suitable.

Table 9-1. Physical and Land-Use Characteristics of Watersheds in the Interior Coast Range BPG. Sub-watersheds are shown in parentheses).

PHYSICAL CHARACTERISTICS					LAND USE				
WATERSHEDS (north to south)	**Area** (acres)[1]	**Area** (sq.miles)[1]	**Stream Length**[2] (miles)	**Ave. Ann. Rainfall**[3] (inches)	**Total Human Population**[4]	**Public Ownership***	**Urban Area**[5]	**Agriculture/ Barren**[5]	**Open Space**[5]
Pajaro River	838,776	1,311	1,843	16.9	235,807	7%	4%	14%	83%
Lower Salinas Basin	1,255,902	1,962	2,598	16.5	286,853	14%	3%	19%	78%
(Gabilan Creek)	(99,929)	(156)	(247)	(18.9)	(154,907)	(0%)	---	---	---
(Arroyo Seco)	(196,430)	(307)	(477)	(18.5)	(920)	(58%)	---	---	---
Upper Salinas Basin	1,576,869	2,464	3,332	16.4	95,399	24%	1%	4%	94%
(San Antonio River and Nacimiento River combined)	(456,758)	(714)	(1,030)	(17.4)	(4,598)	(55%)	---	---	---
TOTAL or AVERAGE	**3,671,547****	**5,737****	**7,773****	**17.4**	**778,484****	**15%****	**3%**	**12%**	**85%**

[1] From: CDFFP CalWater 2.2 Watershed delineation, 1999 (www.ca.nrcs.usda.gov/features/calwater/)
[2] From: CDFG 1:1,000,000 Routed stream network, 2003 (www.calfish.org/)
[3] From: USGS Hydrologic landscape regions of the U.S., 2003 (1 km grid cells)
[4] From: CDFFP Census 2010 block data (migrated), CalFire FRAP (http://frap.cdf.ca.gov/data/frapgisdata/select.asp)
[5] From: CDFFP Multi-source land cover data (v02_2), 2002 (100 m grid cells) (http://frap.cdf.ca.gov/data/frapgisdata/select.asp)
** Includes National Forest Lands and Military Reservations; does not include State or County Parks (from: http://old.casil.ucdavis.edu/casil/gis.ca.gov/teale/govtowna/)*
*** Total or average for Pajaro River watershed (including Uvas Creek sub-watershed), Lower Salinas Basin (including Gabilan Creek and Arroyo Seco sub-watersheds), and Upper Salinas Basin (including San Antonio River and Nacimiento River sub-watersheds)*

9.4 THREATS AND THREAT SOURCES

Information identified in the CAP Workbooks on habitat and land-use indicators for the Interior Coast Range BPG was supplemented by additional information developed since the preparation of the CAP Workbooks and incorporated into the threat assessment. Varying numbers and intensities of habitat impairments (sources of threats) were identified in the CAP Workbooks analyses for the Interior Coast Range BPG, ranging from seven sources in the Nacimiento River and San Antonio River watersheds to 16 in the Salinas River mainstem; additional information developed since the preparation of the CAP has also been incorporated into the threat assessment. The level of threat severity is generally very high in all watersheds in this BPG, but especially in Uvas Creek and along the mainstem Pajaro and Lower Salinas rivers. Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b; see also, California Department of Fish and Game 2011b, Casagrande 2011, 2003, 2001, Central Coast Salmon Enhancement 2008, Casagrande and Watson 2006, Casagrande and Hager 2003, Smith 2007a, 2007b, 1982, Upper Salinas-Las Tables Resource Conservation District 2004, Hager 2001, Hagar Environmental Science 2006, 2005a, 2005b, 2003, 2001, Monterey County Water Resources Agency 2005, San Benito County Water District 2006, Santa Clara Valley Water District 2006, Londquist 2001, Watson *et al.* 2000, Stephenson and Calcarone 1999, Sundermeyer 1999, Harvey & Stanley 1983).

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Ten anthropogenic activities ranked as the top five sources of stress to anadromous *O. mykiss* viability in this BPG (Table 9-2). These sources are not mutually exclusive and can be grouped into the following four general threat categories: 1) barriers to upstream and downstream migration (roads, dams, groundwater extraction, sand and gravel mining); 2) agricultural conversion of floodplain habitats; 3) recreational facilities and activities, and 4) water management activities (dam operations, diversions, groundwater extractions). (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b)

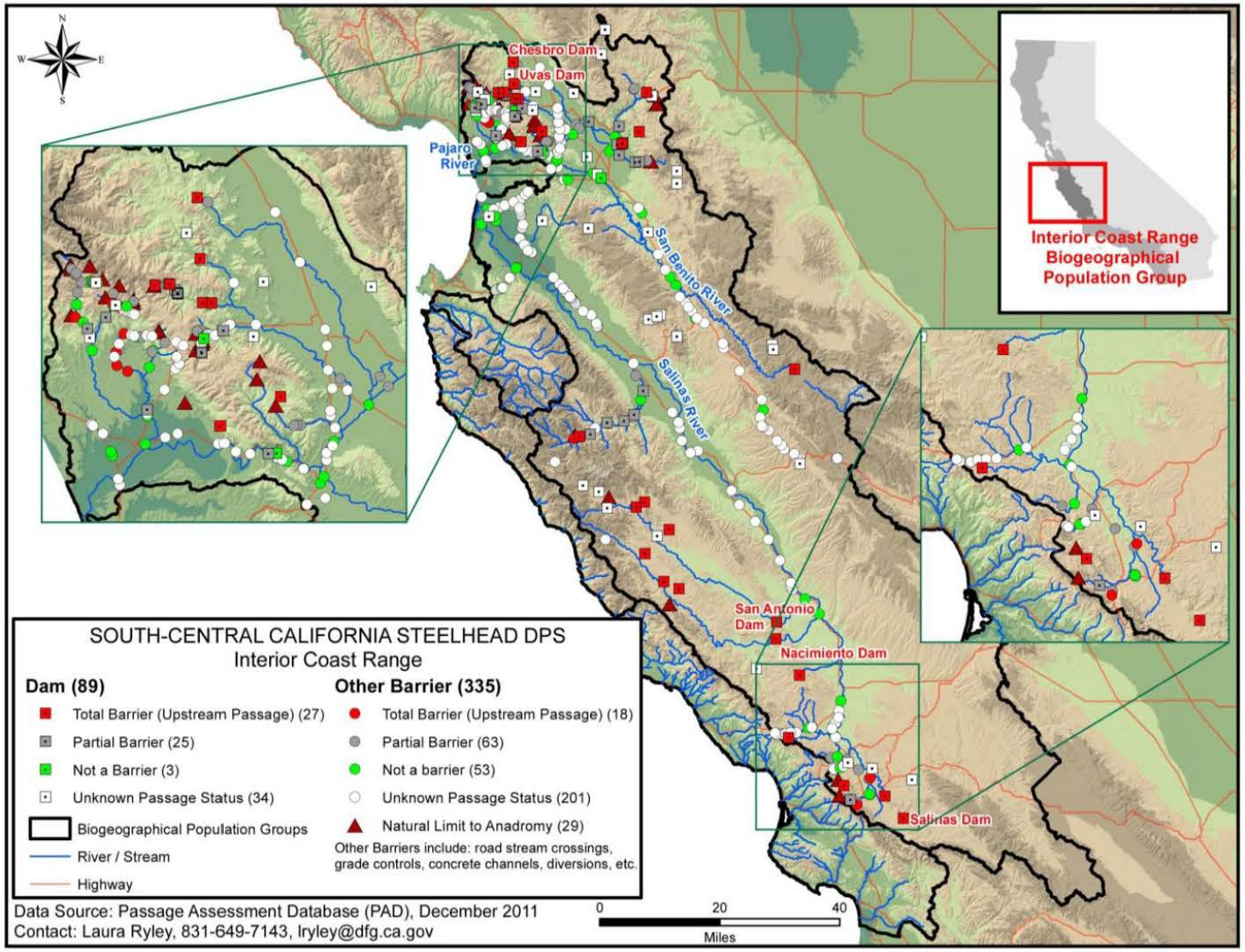

Figure 9-4. Major Fish Passage Impediments, Interior Coast Range BPG.

Table 9-2. Threat source rankings in each component watershed in the Interior Coast Range BPG (see CAP Workbooks for details).

Interior Coast Range BPG Component Watersheds (north to south)							
THREAT* SOURCES	Uvas Creek	Pajaro River Mainstem	Salinas River Mainstem	Gabilan Creek	Arroyo Seco	San Antonio River	Nacimiento River
Dams and Surface Water Diversions							
Groundwater Extraction							
Agricultural Development							
Recreational Facilities							
Levees and Channelization							
Non-Native Species							
Urban Development							
Flood Control Maintenance							
Agricultural Effluents							
Roads							
Culverts and Road Crossings (Passage Barriers)							

Key: Threat cell colors represent threat rating from CAP Workbook: Red = Very High threat; Yellow = High threat; Light green = Medium threat; Dark green = Low threat

**Wildfires were not identified during the CAP Workbook analyses as one of the top five threats in these watersheds, but wildfires within the headwaters of Gabilan Creek (Fremont Peak) in the northern Gabilan Range, as well as wildfires in the tributaries of the Salinas River could be a significant threat to these populations.*

9.5 SUMMARY

Dams and water diversions (including groundwater extractions) on the major rivers of the Interior Coast Range BPG (Salinas and Pajaro rivers) have had the most severe adverse impacts on steelhead populations, reducing and degrading mainstem habitats (including spawning and rearing habitats), cutting off access to upstream spawning and rearing habitats, and altering the magnitude, duration, and timing of flows necessary for immigration of adults and emigration of juveniles throughout the watersheds. Additionally, land-use practices in the Pajaro Valley, particularly conversion of the riparian corridor to agricultural and other land uses, and associated flood control practices including channelization and periodic clearance of the channel of native vegetation and other natural stream features have significantly impacted this important steelhead bearing watershed. Numerous small fish passage barriers have also cumulatively impacted the Pajaro River system by preventing or prohibiting the natural rates of migration of fish (both adults and juvenile) between the ocean and estuary and upstream spawning and rearing habitats. Table 9-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG. Recovery Action Tables 9-4 through 9-6 provide additional specific recovery actions for the Interior Coast Range Population Group.

Restoring conditions for steelhead passage, spawning, and/or rearing in these watersheds will require multiple, long-term measures related to water management, recreation, and barrier removal or modification to allow effective fish passage. Promoting rain water harvesting and off-channel storage of winter "surplus" flows and other innovative water use practices in tributary streams (*e.g.*, Uvas, Little Arthur, Bodfish, and Gabilan Creeks) may be effective alternative water management practices to address the impacts of existing water extractions in smaller watersheds. Impediments to fish passage stemming from the construction and operation of dams and groundwater extractions (*e.g.,* the mainstems and tributaries of the Pajaro River and the Salinas River), modification of channel morphology and adjacent riparian habitats for flood control, and other instream activities such as sand and gravel mining need to be further evaluated for this BPG. Additionally, the loss of estuarine functions caused by filling and pollution from point and non-point agricultural and other anthropogenic waste discharges need to be addressed further in this region.

The threats sources discussed in this section should be the focus of a variety of recovery actions to address specific stresses to anadromous *O. mykiss* viability. Spatial and temporal data acquired on specific indicators associated with threat sources or stresses, such as water temperature, pH, nutrients, *etc*., are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigation in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Interior Coast Range BPG. Recovery Action Tables 9-4 through 9-6 below rank and describe proposed recovery actions for each sub-watershed in the Interior Coast Range BPG including the estimated cost for implementing such actions in five year increments, and where applicable extended out to 100 years, though many of the recovery actions can and should be achieved within a shorter period (Hunt & Associates 2008a 2008b, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

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

POPULATION	CRITICAL RECOVERY ACTIONS
Pajaro River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases from Uvas Dam to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify Uvas 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 ocean. Manage instream mining to minimize impacts to migration, spawning, and rearing habitat. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
Salinas	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases from Salinas Dam 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, 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. Manage instream mining to minimize impacts to migration, spawning, and rearing habitat. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
San Antonio River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions and dams (*e.g.,* San Antonio Dam), to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. 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 ocean.
Nacimiento River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions and dams (*e.g.,* Nacimiento Dam) to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify Nacimiento 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.

South-Central California Coast Steelhead DPS Recovery Action Tables Identification Key, Interior Coast Range BPG (Tables 9-4 to 9-6).

Recovery Action Number Key: XXXX – SCCCS – 1.2	
XXXX	Watershed
SCCCS	Species Identifier – South-Central California Coast Steelhead
1	Threat Source
2	Action Identity Number

Action Rank	
A	Action addresses the first listing factor regarding the destruction or curtailment of the species' habitat
B	Action addresses one of the other four listing factors

XXXX ID Table	
Paj	Pajaro River
UC	Uvas Creek
Sal	Salinas River
GC	Gabilan Creek
AS	Arroyo Seco
SAnt	San Antonio
Nac	Nacimiento

Threat Source Legend	
1	Agricultural Development
2	Agricultural Effluents
3	Culverts and Road Crossings (Passage Barriers)
4	Dams and Surface Water Diversions
5	Flood Control Maintenance
6	Groundwater Extraction
7	Levees and Channelization
8	Mining and Quarrying
9	Non-Native Species
10	Recreational Facilities
11	Roads
12	Upslope/Upstream Activities
13	Urban Development
14	Urban Effluents
15	Wildfires

See Chapter 8, Table 8-1 for Detailed Description of Recovery Actions. See Appendix E for discussion of recovery action cost estimates.

Table 9-4. South-Central California Coast Steelhead DPS Recovery Action Table for Pajaro River Sub-Watersheds (Interior Coast Range BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Pajaro River												
Paj-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, USGS, SBC, SCC, SCRC, RCDMC, SCRC, MC, COG, COW, TWI, TU, CT, CHEER	Agricultural Development	1, 4,	1B	20	0	0	0	0	0	0
Paj-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, USGS, SBC, SCC, SCRC, MC, RCDMC, SCRC, COG, COW,TWI, TU, CT, CHEER	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
Paj-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, USGS, SBC SCC, SCRC, MC, RCDMC, SCRC, COG, COW,TWI, TU, CT, CHEER	Agricultural Development	1, 4,	1B	5	0	0	0	0	0	0
Paj-SCCCS-2.1	Develop and implement a plan to minimize runoff from agricultural activities	NRCS, BLM, USGS, SBC, SCC, SCRC, RCDMC, SCRC, MC, COG, COW,RWQCB, TU, CT, CHEER	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
Paj-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	NMFS, USFS, CDFG, RCDMC, SCRC, MC, COG, COW, CDOT, TWI, CT, TU, CHEER	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
Paj-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers within the watershed	NMFS, SCRC, MC, RCDMC, COG, COW, CDFG, CDOT, TWI, CT, TU, CHEER	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Paj-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFG, SWRCB, SCRC, MC, RCDMC, SCVWD, TWI, ACWA, CT, TU, CHEER	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Paj-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, CDFG, SWRCB, SCRC, MC, RCDMC,SCVWD, TWI, ACWA, CT, TU, CHEER	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Paj-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, CDFG, SWRCB,SCRC, RCDMC, SCVWD, , TWI, ACWA, CT, TU, CHEER	Dams and Surface Water Diversions	1, 3, 4	1A	5	TBD	TBD	TBD	TBD	TBD	TBD
Paj-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, MC, USGS,SCRC, RCDMC, CDFG, TWI, CT, TU, CHEER	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
Paj-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	USGS, NMFS, CDFG, SCRC, RCDMC, SCVWD, TWI, TU, CT, CHEER	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
Paj-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	USGS, NMFS, CDFG, SCRC, SCVWD, TWI, TU, CT, CHEER	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
Paj-SCCCS-7.1	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees.	FEMA, USGS, ACOE, BLM, NRCS, SCRC, RCDMC, SCVWD, NMFS, CDFG, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
Paj-SCCCS-7.2	Develop and implement a plan to restore natural	CSCC, NMFS, CDFG,SCRC, MC, RCDMC, SCVWD,	Levees and Channelization	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	channel features	TWI, TU, CT, CHEER										
Paj-SCCCS-7.3	Develop and implement a stream bank and riparian corridor restoration plan	CSCC, NMFS, CDFG, SCRC, MC, RCDMC, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
Paj-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, NMFS, CDFG, NRCS, RCDMC, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
Paj-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, NMFS, CDFG, NRCS, RCDM, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
Paj-SCCCS-9.3	Develop and implement a public education program on non-native species impacts	USFWS, NMFS, CDFG, NRCS, RCDMC, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
Paj-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests	USFWS, CSCC, CDFG, TU, CT, CHEER	Recreational Facilities	1, 2, 3, 4, 5	3B	20	0	0	0	0	0	0
Paj-SCCCS-	Develop and implement public	USFWS, CSCC, CDFG, TWI, TU, CT,	Recreational Facilities	1,2, 3, 4, 5	3B	20	76140	76140	76140	76140	0	304560

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
10.2	education program on watershed processes	CHEER										
Paj-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, USFWS, CSCC, CDFG, TWI, TU, CT, CHEER	Roads	1, 4	2B	20	0	0	0	0	0	0
Paj-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	DOT, USFWS, CSCC, CDFG, TWI, TU, CT, CHEER	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
Paj-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	DOT, USFWS, CSCC, CDFG, TWI, TU, CT, CHEER	Roads	1, 4	2B	20	0	0	0	0	0	0
Paj-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFWS, EPA, NMFS, NFWF,CDFG, TU, CT, CHEER	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	8174000	0	0	0	0	8174000
Paj-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCOM, CDFG, NMFS, RCDMC, SCRC, MC, TWI, TU, CT, CHEER	Upslope/Upstream Activities	1, 2, 3, 4, 5	1B	5	62400	0	0	0	0	62400
Paj-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	NMFS, CDFG, SCRC, MC, TU, CT, CHEER	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
Paj-SCCCS-13.2	Retrofit storm drains in developed areas	RWQCB, DFG, RCDMC, NMFS, DOT, CDFG, SCRC, MC, TU, CT, CHEER	Urban Development	1, 4	2B	20	0	0	0	0	0	0
Paj-SCCCS 13.3	Develop and implement riparian restoration plan to	ACOE, NRCS, NMFS, RCDMC, SCRC, MC, CDFG,	Urban Development	1,4	2B	5	398000	0	0	0	0	398000

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	replace artificial bank stabilization structures	TU, CT, CHEER										
Paj-SCCCS-14.1	Review California Regional Water Quality Control Board Region Basin Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, NRCS, NMFS, CDFG, SCRC, MC, TU, CT, CHEER	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0
Paj-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCB, SWRCB, NMFS, SCRC, MC, CDFG, TU, CT, CHEER	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Uvas Creek												
UC-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, CDFG, USGS, SB, SCC, SCRC, RCDSC, TWI, TU, CT, CHEER	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
UC-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, CDFG, USGS, SBCC, SCRC, RSDSC, TWI, TU, CT, CHEER	Agricultural Development	1, 4,	1B	5	47520	0	0	0	0	47520
UC-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, CDFG, USGS, SCC, SCRC, RSDSC, TWI, TU, CT, CHEER	Agricultural Development	1, 4,	3B	5	0	0	0	0	0	0
UC-SCCCS-2.1	Develop and implement a plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, CDFG, USGS, SCC, SCRC, RSDSC, TWI, TU, CT, CHEER	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
UC-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	NMFS, USFS, CDFG, SCRC, RSDSC, CDOT, TWI, CT, TU, CHEER	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
UC-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers within the watershed	NMFS, USFS, CDFG, SCRC, RSDSC, CDOT, TWI, CT, TU, CHEER	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
UC-SCCCS-4.1	Develop and implement water management plan	NMFS, CDFG, SWRCB, SCRC,	Dams and Surface Water	1, 3, 4	1A	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	for diversion operations	RSDSC, TWI, ACWA, CT, TU, CHEER	Diversions									
UC-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, CDFG, SWRCB, SCRC, RSDSC, TWI, ACWA, CT, TU, CHEER	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
UC-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, CDFG, SWRCB,SCRC, RSDSC, TWI, ACWA, CT, TU, CHEER	Dams and Surface Water Diversions	1, 3, 4	1A	5	TBD	TBD	TBD	TBD	TBD	TBD
UC-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, USGS,SCRC, RSDSC, CDFG, TWI, CT, TU, CHEER	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
UC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	USGS, NMFS, CDFG, SCRC, RSDSC, TWI, TU, CT, CHEER	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
UC-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	USGS, NMFS, CDFG, SCRC, RSDSC, TWI, TU, CT, CHEER	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
UC-SCCCS-7.1	Develop and implement a plan to restore natural channel features	FEMA, USGS, ACOE, BLM, NRCS, SCRC, NMFS, RSDSC, CDFG, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500
UC-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	FEMA, CSCC, NMFS, CDFG, SCRC, RSDSC, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
UC-SCCCS-7.3	Develop and implement stream bank and riparian corridor restoration plan	FEMA, CSCC, NMFS, CDFG, SCRC, RSDSC, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
UC-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
UC-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
UC-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
UC-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests	USFWS, CSCC, CDFG, CCRP, SCRC,WCB.TWI, TU, CT, CHEER	Recreational Facilities	1, 3, 5	3B	20	0	0	0	0	0	0
UC-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, CSCC, CDFG, CCRP, SCRC,WCB,TWI, TU, CT, CHEER	Recreational Facilities	1, 2, 4	3B	20	76140	76140	76140	76140	0	304560
UC-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, CDOT,USFWS, SCRC, CDFG, TWI, TU, CT, CHEER	Roads	1, 4	2B	20	0	0	0	0	0	0
UC-SCCCS 11.2	Retrofit storm drains to filter runoff from roadways	DOT, CDOT, USFWS, SCRC, CDFG, TWI, TU, CT, CHEER	Roads	1,4	2B	20	32260	32260	32260	32260	0	129040

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
UC-SCCCS11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	DOT, CDOT, USFWS, SCRC, CDFG, TWI, TU, CT, CHEER	Roads	1,4	2B	20	0	0	0	0	0	0
UC-SCCCS-12.1	Review and modify applicable County and/or City Local Coastal Plans	CCOM, SCRC, CDFG, NMFS, TWI, TU, CT, CHEER	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
UC-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	SCRC, NMFS, CDFG,SCRC, TU, CT, CHEER	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
UC-SCCCS-13.2	Retrofit storm drains in developed areas	SCRC, ACOE, NRCS, NMFS, SCRC, CDFG, TU, CT, CHEER	Urban Development	1, 4	2B	20	0	0	0	0	0	0
UC-SCCCS-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	SCRC, ACOE, NRCS, NMFS,SCRC, CDFG, TU, CT, CHEER	Urban Development	1,4	2B	5	398000	0	0	0	0	398000
UC-SCCCS-14.1	Review California Regional Water Quality Control Boards Coast Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, NRCS, SCRC, NMFS, CDFG, TU, CT, CHEER	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
UC-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCB, SWRCB, NMFS, SCRC, CDFG, TU, CT, CHEER	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0

Table 9-5. South-Central California Coast Steelhead DPS Recovery Action Table for Lower Salinas River Sub-Watersheds (Interior Coast Range BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Salinas River												
Sal-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, USGS, RSDSC, MC,SLOC, NMFS, CDFG, USTRCD, USWC, TWI,TU,TCFT	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
Sal-SCCCS-1.2	Manage agricultural development and restore riparian zones	NRCS, BLM, USGS, RSDMC, MC,SLOC, NMFS, CDFG, USTRCD, USWC, TWI,TU,TCFT	Agricultural Development	1, 4,	1B	5	0	0	0	0	0	0
Sal-SCCCS-1.3	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, USGS, RSDMC, MC,SLOC, NMFS, CDFG, USTRCD, USWC,CSLRCD,TWI,TU,TCFT	Agricultural Development	1, 4,	2B	5	47520	0	0	0	0	47520
Sal-SCCCS-2.1	Develop and implement a plan to minimize runoff from agricultural activities	RWQCB, SWRCB,NRCS, BLM, USGS, NMFS, CDFG, RSDMC, MC,SLOC, USTRCD, USWC, TWI,TU,TCFT	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
Sal-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, MC, FRGP, SLOC, RSDSC, CDOT, USCW, USLTRCD,TWI, CT, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Sal-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers with in the watershed	NMFS, CDFG, CCCON, MC, FRGP, SLOC, RSDMC, CDOT, USCW, USLTRCD,TWI, CT, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
Sal-SCCCS-4.1	Develop and implement water management plan for dam operations	NMFS, CDFG, CCON, MC, MCWRA, FRGP, SLOC, RSDMC, USWC, USLTRCD,TWI, CT, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Sal-SCCCS-4.2	Develop and implement water management plan for diversion operations	NMFS, CDFG, CCON, MC, MCWRA, FRGP, SLOC, RSDMC, USWC, USLTRCD,TWI, CT, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Sal-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, CDFG, CCON, MC, MCWRA,FRGP, SLOC, RSDMC, USWC, USLTRCD,TWI, CT, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	10	TBD	TBD0	TBD	TBD	TBD	TBD
Sal-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, USGS, MC, SLOC, RSDMC, CDFG, TWI, USLTRCD, USWC,CT, TU, TCFT	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
Sal-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	USGS, NMFS, CDFG, MC, SLOC, RSDMC, USLTRDC, USWC,TWI, TU, CT, TCFT	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
Sal-SCCCS-6.2	Develop and implement a groundwater monitoring and	USGS, NMFS, CDFG, MC, SLOC, RSDMC, USLTRDC, USWC,TWI, TU, CT, TCFT	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	management program											
Sal-SCCCS-7.1	Develop and implement a plan to restore natural channel features	FEMA, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RSDMC, CDFG, TWI, USLTRCD, USWC,CT, TU, TCFT	Levees and Channelization	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500
Sal-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	FEMA, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RSDMC, CDFG, TWI, USLTRCD, USWC,CT, TU, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
Sal-SCCCS-7.3	Develop and implement stream bank and riparian corridor restoration plan	FEMA, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RSDMC, CDFG, TWI, USLTRCD, USWC,CT, TU, TCFT	Levees and Channelization	1,4	1B	5	10521940	0	0	0	0	10521940
Sal-SCCCS-8.1	Review and modify mining operations	USGS, NMFS, CDFG, CDMG, MC, SLOC, NRCS, RSDMC, USLTRCD, USWC,CT, TU, TCFT	Mining and Quarrying	1, 4, 5	1B	20	68030	0	0	0	0	68030
Sal-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, RSDMC, USLTRCD, USWC,TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Sal-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, RSDMC, USLTRCD, USWC,TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
Sal-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, RSDMC, USLTRCD, USWC,TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
Sal-SCCCS-10.1	Manage off-road recreational vehicle activity in riparian floodplain corridors	USFWS, USFS, BLM, CDFG, MC, SLOC,,WCB.TWI, USLTRCD, USWC,TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
Sal-SCCCS-10.2	Review and modify development and management plans for recreational areas and national forests	USFWS, USFS, BLM, CDFG, MC, SLOC,,WCB.TWI, USLTRCD, USWC,TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
Sal-SCCCS-10.3	Develop and implement a public educational program on watershed processes	USFWS, USFS, BLM, CDFG, MC, SLOC,,WCB.TWI, USLTRCD, USWC,TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
Sal-SCCCS-	Management roadways and	DOT, CDOT, USFWS, MC, SLOC, CDFG, USLTRCD,	Roads	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
11.1	adjacent riparian corridor and restore abandoned roadways	USWC,TWI, TU, CT, TCFT										
Sal-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	DOT, CDOT, USFWS, RWQCB, MC, SLOC, CDFG, USLTRCD, USWC,TWI, TU, CT, TCFT	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
Sal-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	DOT, CDOT, USFWS, MC, SLOC, CDFG, USLTRCD, USWC,TWI, TU, CT, TCFT	Roads	1,4	2B	20	0	0	0	0	0	0
Sal-SCCCS-12.1	Develop and implement a restoration an estuary restoration and management plan	USFWS, EPA, NMFS, NFWF,CDFG, TU, CT, ESF	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	29949000	0	0	0	0	29949000
Sal-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCOM, SCRC, CDFG, NMFS, MC, SLOC, USLTRCD, USWC,TWI, TU, CT, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1B	5	62400	0	0	0	0	62400
Sal-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	NMFS, CDFG, MC, SLOC, USLTRCD, USWC, TU, CT, TCFT	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
Sal-SCCCS-13.2	Retrofit storm drains in developed	RWQCB, NMFS, CDFG, MC, SLOC, USLTRCD, USWC, TU, CT, TCFT	Urban Development	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	areas											
Sal-SCCCS-14.1	Review California Regional Water Quality Control Boards Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, NMFS, MC, SLOC, CDFG, USLTRCD, USWC,TU, CT, TCFT	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0
Sal-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* City of Paso Robles Wastewater Treatment Facility)	RWQCB, SWRCB, NMFS, MC, SLOC, CDFG, USLTRCD, USWC,TU, CT, TCFT	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Gabilan Creek												
GC-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, CDFG, USGS, SCC, , RSDSC, SCRC, TWI, TU, CT, CHEER	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
GC-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, CDFG, USGS, SCC, , RSDSC, SCRC, TWI, TU, CT, CHEER	Agricultural Development	1, 4,	1B	5	47520	0	0	0	0	47520
GC-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, CDFG, USGS, SCC, , RSDSC, SCRC, TWI, TU, CT, CHEER	Agricultural Development	1, 4,	2B	5	0	0	0	0	0	0
GC-SCCCS-2.1	Develop and implement a plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, RWQCB, SWRCB, CDFG, USGS, SCC, , RSDSC, SCRC, TWI, TU, CT, CHEER	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
GC-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment (or periodically up-date)	NMFS, USFS, CDFG, SCRC, RSDSC, CDOT, TWI, CT, TU, CHEER	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
GC-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers within the watershed	NMFS, USFS, CDFG, SCRC, RSDSC, CDOT, TWI, CT, TU, CHEER	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
GC-SCCCS-4.1	Develop and implement water management plan for any future diversion operations	NMFS, CDFG, SWRCB, SCRC, RSDSC, TWI, ACWA, CT, TU, CHEER	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
GC-SCCCS-4.2	Develop and implement water management plan for any future dam operations	NMFS, CDFG, SWRCB, SCRC, RSDSC, TWI, ACWA, CT, TU, CHEER	Dam and Surface Water Diversions	1,3,4	1A	5	91850	0	0	0	0	91850
GC-SCCCS-4.3	Provide fish passage around any future dams and diversions	NMFS, CDFG, SWRCB, SCRC, RSDSC, TWI, ACWA, CT, TU, CHEER	Dams and Surface Water Diversions	1,3, 4	1A	5	0	0	0	0	0	0
GC-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, USGS,SCRC, RSDSC, CDFG, TWI, CT, TU, CHEER	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
GC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	USGS, NMFS, CDFG, SCRC, RSDSC, TWI, TU, CT, CHEER	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
GC-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	USGS, NMFS, CDFG, SCRC, RSDSC, TWI, TU, CT, CHEER	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
GC-SCCCS-7.1	Develop and implement plan to restore natural channel features	FEMA, USGS, NMFS, CDFG ACOE, BLM, NRCS, SCRC, RSDSC, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500
GC-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near	FEMA, USGS, NMFS, CDFG, ACOE, BLM,	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	levees	NRCS, SCRC, RSDSC, TWI, TU, CT, CHEER										
GC-SCCCS-7.3	Develop and implement stream bank and riparian corridor restoration plan	FEMA, USGS, NMFS, CDFG, ACOE, BLM, NRCS, SCRC, RSDSC,TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
GC-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
GC-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
GC-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts (or periodically update)	USFWS, NMFS, CDFG, SCRC, RSDSC, NRCS, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
GC-SCCCS-10.1	Develop and implement a public educational program on watershed processes (or periodically update)	USFWS, CSCC, CDFG, CCRP, SCRC,WCB.TWI, TU, CT, CHEER	Recreational Facilities	1, 2, 3,4, 5	3B	20	76140	76140	76140	76140	0	304560
GC-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, CDOT,USFWS, SCRC, CDFG, TWI, TU, CT, CHEER	Roads	1, 4	2B	20	0	0	0	0	0	0
GC-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	DOT, CDOT,USFWS, SCRC, CDFG, TWI, TU, CT, CHEER	Roads	1,4	2B	20	32260	32260	32260	32260	0	129040

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
GC-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	DOT, CDOT,USFWS, SCRC, CDFG, TWI, TU, CT, CHEER	Roads	1,4	2B	20	0	0	0	0	0	0
GC-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	SCRC, NMFS, CDFG,SCRC, TU, CT, CHEER	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
GC-SCCCS-13.2	Retrofit storm drains in developed areas	SCRC, ACOE, NRCS, NMFS,SCRC, CDFG, TU, CT, CHEER	Urban Development	1, 4	2B	20	0	0	0	0	0	0
GC-SCCCS-14.1	Review California Regional Water Quality Control Boards Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, NRCS, SCRC, NMFS, CDFG, TU, CT, CHEER	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
GC-SCCCS-14.2	Review, assess and modify NPDES wastewater discharge permits	RWQCB, SWRCB, NMFS, SCRC, CDFG, TU, CT, CHEER	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Arroyo Seco												
AS-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, USGS, RSDMC, MC, NMFS, CDFG, USTRCD, TWI,TU, ASRA,	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
AS-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, USGS, RCDMC, MC,SLOC, NMFS, CDFG, TWI,TU, ASRA	Agricultural Development	1, 4,	1B	5	47520	0	0	0	0	47520
AS-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, USGS, RCDMC, MC,SLOC, NMFS, CDFG, TWI,TU, ASRA	Agricultural Development	1, 4,	2B	5	0	0	0	0	0	0
AS-SCCCS-2.1	Develop and implement a plan to minimize runoff from agricultural activities	NRCS, BLM, USGS, RCDMC, RWQCB, SWRCB,MC,SLOC, NMFS, CDFG, TWI,TU, ASRA	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
AS-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	NMFS, USFS, USFWS, CDFG, CCCON, MC, FRGP, RCDMC, CDOT, TWI, CT, TU, ASRA	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
AS-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers within the watershed (*e.g.,* Sycamore Flats, Miller's Lodge, Clark Colony, *etc.*)	NMFS, USFW, USFS, CDFG, CCCON, MC, FRGP, RCDMC, CDOT, TWI, CT,TU, ASRA	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
AS-SCCCS-4.1	Develop and implement water management plan for any future dam operations	NMFS, USFS, USFWS, CDFG, CCON, MC,	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		MCWRA, FRGP, RSDMC, TWI, CT, TU, ASRA										
AS-SCCCS-4.2	Develop and implement water management plan for any future diversion operations	NMFS,USFS, USFWS, CDFG, CCON, MC, MCWRA, FRGP, RCDMC,TWI, CT, TU, ASRA	Dams and Surface Water Diversions	1,3, 4	1A	100	0	0	0	0	0	0
AS-SCCCS-4.1	Provide fish passage around any future dams and diversions	NMFS, CDFG, CCON, MC, MCWRA, FRGP, RCDSC, TWI, CT, TU, ASRA	Dams and Surface Water Diversions	1, 3, 4	1A	100	TBD	TBD	TBD	TBD	TBD	TBD
AS-SCCCS-5.1	Develop and implement flood control maintenance program (or periodically update)	ACOE, USFS, USFWS, NMFS, CDFG, NRCS, USGS, MC, RCDMC, CDFG, TWI, CT, TU, ASRA	Flood Control Maintenance	1, 4	3B	100	0	0	0	0	0	0
AS-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	USGS, NMFS, CDFG, MC, RCDMC, TWI, TU, CT, ASRA	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
AS-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	USGS, NMFS, CDFG, MC, RCDSC, TWI, TU, CT, ASRA	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
AS-SCCCS-7.1	Develop and implement a plan to restore natural channel features	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, RCDMC, CDFG, TWI, CT, TU, ASRA	Levees and Channelization	1, 4	2B	20	4217625	4217625	4217625	4217625	0	16870500

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
AS-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, RCDMC, CDFG, TWI, CT, TU, ASRA	Levees and Channelization	1, 4	2B	100	0	0	0	0	0	0
AS-SCCCS-7.3	Develop and implement stream bank and riparian corridor restoration plan	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, RCDMC, CDFG, TWI, CT, TU, ASRA	Levees and Channelization	1,4	2B	5	10521940	0	0	0	0	10521940
AS-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, RSDMC, NRCS, RCDMC, TWI, TU, CT, ASRA	Non-Native Species	1, 3,5	2B	100	0	0	0	0	0	0
AS-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, RCDMC, NRCS, RSDMC, TWI, TU, CT, ASRA	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
AS-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, RCDMC, NRCS, RCDSC, TWI, TU, CT, ASRA	Non-Native Species	1, 3, 5	2B	20	76140	76140	76140	76140	0	304560
AS-SCCCS-10.1	Manage off-road recreational vehicle activity in riparian floodplain corridors	USFWS, USFS, BLM, CDFG, MC, WCB.TWI, TU, CT, ASRA	Recreational Facilities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
AS-SCCCS-10.2	Review and modify development and management plans for recreational areas and national forests	USFWS, USFS, BLM, CDFG, MC, WCB.TWI, TU, CT, ASRA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
AS-SCCCS-10.3	Develop and implement a public educational program on watershed processes	USFWS, USFS, BLM, CDFG, MC, WCB.TWI, TU, CT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
AS-SCCCS-11,1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, CDOT, USFWS, MC, RCDMC,CDFG, TWI, TU, CT, ASRA	Roads	1, 4	2B	20	0	0	0	0	0	0
AS-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	DOT, CDOT, USFWS, MC, RCDMC,CDFG, TWI, TU, CT, ASRA	Roads	1,4	2B	20	32260	32260	32260	32260	0	129040
AS-SCCCS-13.1	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	USFS, USFWS, NMFS, RCDMC, DFG, MC, TU, CT	Urban Development	1, 4	3B	5	398000	0	0	0	0	398000
AS-SCCCS-14.1	Review California Regional Water Quality Control Board Central Coast Region Basin Plans and modify applicable stormwater permits	USFS, NMFS, RCDSC, RWQCB, SWRCB, DFG, MC, TU, CT, ASRA	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
AS-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	USFS, NMFS, RCDMC, RWQCB, SWRCB, DFG, MC, TU, CT, ASRA	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0

Table 9-6. South-Central California Coast Steelhead DPS Recovery Action Table for Upper Salinas River Sub-Watersheds (Interior Coast Range BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
San Antonio												
SAnt-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, USGS, RCDMC, MC, SLOC, NMFS, CDFG, TWI,TU, TCFT	Agricultural Development	1, 4	2B	20	0	0	0	0	0	0
SAnt-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, USGS, RCDMC, MC, SLOC, NMFS, CDFG, TWI,TU, TCFT	Agricultural Development	1, 4,	2B	5	47520	0	0	0	0	47520
SAnt-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, USGS, RCDMC, MC, SLOC, NMFS, CDFG, TWI,TU, TCFT	Agricultural Development	1, 4,	3B	5	0	0	0	0	0	0
SAnt-SCCCS-2.1	Develop and implement a plan to minimize runoff from agricultural activities	NRCS, BLM, USGS, RCDMC, RWQCB, SWRCB,MC,SLOC, NMFS, CDFG, TWI,TU, TCFT	Agricultural Effluents	1, 4	3B	100	0	0	0	0	0	0
SAnt-SCCCS-3.1	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, USFS, USFWS, CDFG, CCCON, MC, SLOC, FRGP, RCDMC, CDOT, TWI, CT, TU, TCFT	Culverts and Road Crossings (Passage Barriers)	1,4	1B	5	0	0	0	0	0	0
SAnt-SCCCS-3.2	Conduct watershed-wide fish passage barrier assessment	NMFS, USFS, USFWS, CDFG, CCCON, MC, SLOC, FRGP, RCDMC, CDOT, TWI, CT, TU, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1B	5	96690	0	0	0	0	96690

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SAnt-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, USFWS, CDFG, CCON, MC, SLOC, MCWRA, FRGP, RCDMC, TWI, CT, TU, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
SAnt-SCCCS-4.2	Develop and implement water management plan for dam operations (or periodically update)	NMFS, USFS, USFWS, CDFG, CCON, MC, SLOC, MCWRA, FRGP, RCDMC, TWI, CT, TU, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
SAnt-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, USFS, USFWS, CDFG, CCON, MC, SLOC, MCWRA, FRGP, RCDMC, TWI, CT, TU, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	10	TBD	TBD	TBD	TBD	TBD	TBD
SAnt-SCCCS-5.1	Develop and implement flood control maintenance program (or periodically update)	ACOE, USFS, USFWS, NMFS, CDFG, NRCS, USGS, MC, RCDMC, CDFG, TWI, CT, TU, TCFT	Flood Control Maintenance	1, 4	2B	100	0	0	0	0	0	0
SAnt-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	USGS, NMFS, DWR, CDFG, MC, RCDMC, TWI, TU, CT, TCFT	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
SAnt-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	USGS, NMFS, DWR, CDFG, MC, RCDMC, TWI, TU, CT, TCFT	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
SAnt-SCCCS-7.1	Develop and implement plan to restore natural channel features	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RCDMC, CDFG, TWI, CT,	Levees and Channelization	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		TU, TCFT										
SAnt-SCCCS-7.2	Develop and implement stream bank and riparian corridor restoration plan	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RCDMC, CDFG, TWI, CT, TU, TCFT	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
SAnt-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, MC, SLOC, RCDMC, MCWRA, NRCS, TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
SAnt-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, MC, SLOC, RCDMC, MCWRA, NRCS, TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
SAnt-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, MC, SLOC, RCDMC, MCWRA, NRCS, TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	2B	20	76140	76140	76140	76140	0	304560
SAnt-SCCCS-10.1	Manage off-road recreational vehicle activity in riparian floodplain corridors	USFWS, USFS, USA, BLM, NMFS, CDFG, MC, MCWRA, WCB.TWI, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
SAnt-SCCCS-10.2	Review and modify development and management plans for recreational areas and national forests.	USFWS, USFS, USA, BLM, NMFS, CDFG, MC, MCWRA, WCB.TWI, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SAnt-SCCCS-10.3	Develop and implement a public educational program on watershed processes	USFWS, USFS, USA, BLM, NMFS, CDFG, MC, MCWRA, WCB.TWI, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
SAnt-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, USA, CDOT, USFWS, MC, SLOC, MCWRA, RCDMC,CDFG, TWI, TU, CT, TCFT	Roads	1, 4	2B	20	0	0	0	0	0	0
SAnt-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	DOT, USA, CDOT, USFWS, RWQCB, SWRCB, MC, SLOC, MCWRA, RCDMC,CDFG, TWI, TU, CT, TCFT	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
SAnt-SCCCS-11.3	Develop and Implement plan to remove or reduce approach-fill for railroad line and roads	DOT, USA, CDOT, USFWS, RWQCB, SWRCB,MC, SLOC, MCWRA, RCDMC,CDFG, TWI, TU, CT, TCFT	Roads	1, 4	2B	20	0	0	0	0	0	0
SAnt-SCCCS-12.1	Review applicable Integrated Natural Resources Management Plans	USA, USFWS, USFW, NMFS, CDFG, MC, MCWRA, RCDMC, TWI,CT, TU, TCFT	Upslope/Upstream Activities	1, 4	2B	20	0	0	0	0	0	0
SAnt-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	USFS, USA, USFWS, NMFS, CDFG, RCDMC, MCWRA,DFG, MC, SLOC, TU, CT, TCFT	Urban Development	1, 4	3B	5	62400	0	0	0	0	62400
SAnt-SCCCS-13.2	Retrofit storm drains in developed areas	USFWS, USA, NMFS, RCDMC, RWQCB, SWRCB, NMFS, DFG, MC,	Urban Development	1, 4	3B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		SLOC, TU, CT, TCFT										
SAnt-SCCCS-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	USFS, USA, USFWS, NMFS, CDFG, RSDSC, MCWRA,DFG, MC, SLOC, TU, CT, TCFT	Urban Development	1, 4	3B	5	398000	0	0	0	0	398000
SAnt-SCCCS-14.1	Review California Regional Water Quality Control Board Central Coast Region Basin Plans and modify applicable stormwater permits	USFS, USA, NMFS, RCDMC, RWQCB, SWRCB, DFG, MC, TU, CT, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
SAnt-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	USFS, USA, NMFS, RCDMC, RWQCB, SWRCB, DFG, MC, TU, CT, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Nacimiento												
Nac-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, USGS, RCDMC SLOC, NMFS, CDFG, CSLRCD, TU, TCFT	Agricultural Development	1, 4	2B	20	47520	0	0	0	0	47520
Nac-SCCCS-1.3	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, USGS, SLOC, NMFS, RCDMC, CDFG, CSLRCD, TU, TCFT	Agricultural Development	1, 4,	2B	5	0	0	0	0	0	0
Nac-SCCCS-1.4	Manage agricultural development and restore riparian zones	NRCS, BLM, USGS, RCDMC, SLOC, NMFS, CDFG, CSLRCD, TU, TCFT	Agricultural Development	1, 4,	3B	5	0	0	0	0	0	0
Nac-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, USFS, USFWS, CDFG, CCCON, RCDMC, SLOC, FRGP, CDOT,CSLRCD, CT, TU, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1B	5	0	0	0	0	0	0
Nac-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, USFS, USFWS, RCDMC CDFG, CCCON, RCDMC, SLOC, FRGP, CDOT,CSLRCD, CT, TU, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1B	5	91850	0	0	0	0	91850
Nac-SCCCS-4.1	Develop and implement water management plan for dam operations (or periodically update)	NMFS, USFS, USFWS, CDFG, CCON, MCWRA,	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		SLOC,, FRGP, CT, TU, TCFT										
Nac-SCCCS-4.2	Develop and implement water management plan for diversion operations (or periodically update)	NMFS, USFS, USFWS, CDFG, CCON, MCWRA, SLOC,, FRGP, CT, TU, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
Nac-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, USFS, USFWS, CDFG, CCON, MCWRA, SLOC,, FRGP, CT, TU, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	10	TBD	TBD	TBD	TBD	TBD	TBD
Nac-SCCCS-5.1	Develop and implement flood control maintenance program (or periodically update)	ACOE, USFS, USFWS, NMFS, CDFG, NRCS, USGS, MC, MCWRA, CSLRCD, CDFG, CT, TU, TCFT	Flood Control Maintenance	1, 4	2B	100	91850	0	0	0	0	91850
Nac-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	USGS, NMFS, CDFG, SLOC, TU, CT, TCFT	Groundwater Extraction	1, 4	1A	5	254350	39775	0	0	0	294125
Nac-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	USGS, NMFS, CDFG, SLOC, TU, CT. TCFT	Groundwater Extraction	1, 4	1A	10	4217625	4217625	4217625	4217625	0	16870500
Nac-SCCCS-7.1	Develop and implement a plan to restore natural channel features	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RSDSC, CSLRCD, CDFG, TWI, CT, TU, TCFT	Levees and Channelization	1, 4	1B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Nac-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RSDSC, CSLRCD, CDFG, TWI, CT, TU, TCFT	Levees and Channelization	1, 4	1B	100	10521940	0	0	0	0	10521940
Nac-SCCCS-7.3	Develop and implement stream bank and riparian corridor restoration plan	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, RCDMC, SLOC, CSLRCD, CDFG, TWI, CT, TU, TCFT	Levees and Channelization	1, 4	2B	5	0	0	0	0	0	0
Nac-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, MC, SLOC, RSDSC, MCWRA, NRCS, RCDMC, TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
Nac-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, MC, SLOC, RCDMC, MCWRA, NRCS, RSDSC, TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	2B	100	76140	76140	76140	76140	0	304560
Nac-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, MC, SLOC, RCDMC,	Non-Native Species	1, 3, 5	2B	20	62400	0	0	0	0	62400

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		MCWRA, NRCS, RCDMC, TWI, TU, CT, TCFT										
Nac-SCCCS-10.1	Manage off-road recreational vehicle activity in riparian floodplain corridors	USFWS, USFS, USA, BLM, NMFS, CDFG, MC, MCWRA, WCB.TWI, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	5	0	0	0	0	0	0
Nac-SCCCS-10.2	Review and modify development and management plans for recreational areas and national forests	USFWS, USFS, USA, BLM, NMFS, CDFG, MC, MCWRA, WCB.TWI, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	62400	0	0	0	0	62400
Nac-SCCCS-10.3	Develop, adopt, and implement recreational land-use planning policies	USFWS, USFS, USA, BLM, NMFS, CDFG, MC, MCWRA, WCB.TWI, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	5	0	0	0	0	0	0
Nac-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, CDOT, USFWS, RWQCB, SWRCB,MC, SLOC, SLOC, MCWRA, CSLRCD, CDFG, TWI, TU, CT, TCFT	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
Nac-SCCCS-11.2	Retrofit storm drains to filter run-off from roadways	DOT, CDOT, USFWS, RWQCB, SWRCB,MC, SLOC, MCWRA, CSLRCD, CDFG, TWI, TU,	Roads	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		CT, TCFT										
Nac-SCCCS-11.3	Develop and implement a plan to remove or reduce approach-fill for railroad lines and roads	DOT, CDOT, USFWS, RWQCB, SWRCB,MC, SLOC, MCWRA, CSLRCD, CDFG, TWI, TU, CT, TCFT	Roads	1, 4	2B	20	0	0	0	0	0	0
Nac-SCCCS-12.1	Review applicable Integrated Natural Resources Management Plans	USA, USFWS, USFW, NMFS, CDFG, MC, MCWRA, RCDMC, TWI,CT, TU, TCFT	Upslope/Upstream Development	1, 4	2B	20	0	0	0	0	0	0
Nac-SCCCS-13.1	Retrofit storm drains in developed areas	USFS, USA, USFWS, NMFS, CDFG, RCDMC, MCWRA,DFG, MC, SLOC, TU, CT, TCFT	Urban Development	1, 4	3B	20	62400	0	0	0	0	62400
Nac-SCCCS-13.2	Develop, adopt, and implement urban land-use planning policies and standards	USFS, USA, USFWS, NMFS, CDFG, RCDMC, MCWRA,DFG, MC, SLOC, TU, CT, TCFT	Urban Development	1, 4	3B	5	398000	0	0	0	0	398000
Nac-SCCCS-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	USFS, USA, USFWS, NMFS, CDFG, RCDMC, MCWRA,DFG, MC, SLOC, TU, CT, TCFT	Urban Development	1, 4	2B	5	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Nac-SCCCS-14.1	Review California Regional Water Quality Control Board Central Coast Region Basin Plans and modify applicable stormwater permits	USFS, USA, NMFS, RCDMC, MC, SLOC, RWQCB, SWRCB, DFG, TU, CT, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
Nac-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* Heritage Ranch Wastewater Treatment Facility)	USFS, USA, NMFS, RCDMC, MC, SLOC, RWQCB, SWRCB, DFG, TU, CT, TCFT	Urban Effluents	1, 4	2B	20	47520	0	0	0	0	47520

10. Carmel River Basin Biogeographic Population Group

"Assessment at the group level indicates a priority for securing inland populations in southern Coast Ranges and Transverse Ranges, and a need to maintain not just the fluvial-anadromous life-history form, but also lagoon-anadromous and freshwater-resident forms in each population."

NOAA Fisheries Technical Recovery Team
Viability Criteria for South-Central and Southern California, 2007

10.1 LOCATION AND PHYSICAL CHARACTERISTICS

The Carmel River Basin Biogeographic Population Group BPG region is one of the smallest of the four BPG regions in the SCCS Recovery Planning Area (Figure 10-1). The main axis of the Carmel River watershed is just 28 miles long. In contrast, the main axis of the neighboring Interior Coast Range BPG region is over 180 miles long.

Upper Carmel River

The Carmel River Basin BPG region drains the eastern slopes of the northern Santa Lucia Range and the western slopes of the Sierra de Salinas in northwestern Monterey County Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service and National Marine Fisheries Service 2008a, 2008b).

Carmel River between Los Padres and San Clemente Dams

The Carmel River flows into the Pacific Ocean at Carmel Bay, just south of the

Monterey Peninsula. This BPG region shares some physical characteristics with the Interior Coast Range BPG region, such as general northwest-southeast watershed orientation, landform evolution largely controlled by tectonic activity associated with the San Andreas Fault, and a highly dissected watershed. There are seven major perennial tributaries to the Carmel River (Figure 10-1). Average annual precipitation in this region is relatively low and shows high spatial variability. In general, the coastal regions and higher elevations receive higher amounts of precipitation. The Carmel River watershed is relatively steep and most of the tributaries are naturally perennial (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

Carmel River Estuary

10.2 LAND USE

Table 10-1 summarizes land use and population density in this region. Human population density is moderate to high and concentrated in the lower and middle portions of the Carmel Valley, including the towns of Carmel and Carmel Valley (March 2012, Palumbi 2011, Chiang 2008, Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Carmel River Watershed Conservancy 2004, Walton 2003, Stephenson and Calcarone 1999, Monterey Peninsula Water Management District 1987, 1983, Kondolf 1986, California Department of Water Resources 1978).

Golf Course Development

Population density averages 70 persons per square mile. Although less than four percent of the watershed is classified as urban, well over 50 percent of the watershed is privately-owned and the Carmel Valley, through which the mainstem flows, is surrounded by extensive ranches and areas of rural land use. Less than one percent of the watershed is under cultivation.

There are four dams in the Carmel River watershed: Black Rock Creek Dam, Old Carmel River Dam, San Clemente Dam, and Los Padres Dam. Black Rock Creek Dam, constructed in 1925 on a tributary to the Carmel River, is used for recreational purposes. The Old Carmel River, San Clemente and Los Padres Dams, were constructed on the mainstem Carmel River in 1880, 1921 and 1949, respectively, for municipal and agricultural water supply (California Department of Fish and Game 2011b, California Department of Water Resources1988).

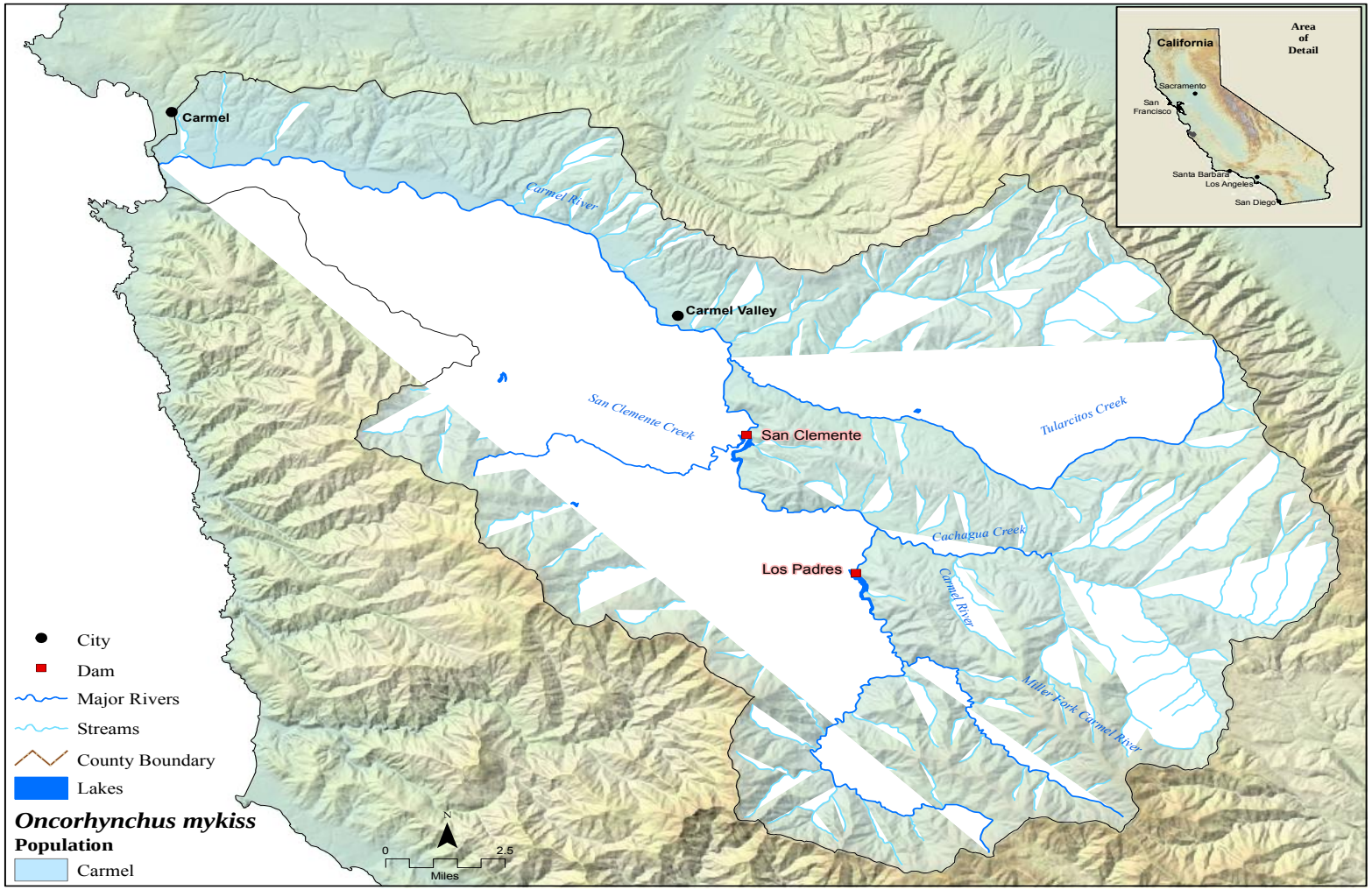

Figure 10-1. The Carmel River Basin BPG region. This BPG region is comprised of a single watershed (Carmel River).

Table 10-1. Physical and Land-Use Characteristics of Watersheds in the Carmel River Basin BPG region.

PHYSICAL CHARACTERISTICS						LAND USE			
WATERSHED	**Area** (acres)[1]	**Area** (sq.miles)[1]	**Stream Length**[2] (miles)	**Ave. Ann. Rainfall**[3] (inches)	**Total Human Population**[4]	**Public Ownership***	**Urban Area**[5]	**Agriculture/ Barren**[5]	**Open Space**[5]
Carmel River	162,286	254	248	19.8	17,020	31%	4%	0.6%	95%

[1] From: CDFFP CalWater 2.2 Watershed delineation, 1999 (www.ca.nrcs.usda.gov/features/calwater/)
[2] From: CDFG 1:1,000,000 Routed stream network, 2003 (www.calfish.org/)
[3] From: USGS Hydrologic landscape regions of the U.S., 2003 (1 km grid cells)
[4] From: CDFFP CalFire FRAP (http://cdf.ca.gov/data/frapisdata/select.sap)(migrated)
[5] From: CDFFP Multi-source land cover data (v02_2), 2002 (100 m grid cells) (http://frap.cdf.ca.gov/data/frapgisdata/select.asp)
** Includes National Forest Lands and Military Reservations only; does not include State or County Parks (from:*

http://old.casil.ucdavis.edu/casil/gis.ca.gov/teale/govtowna/)

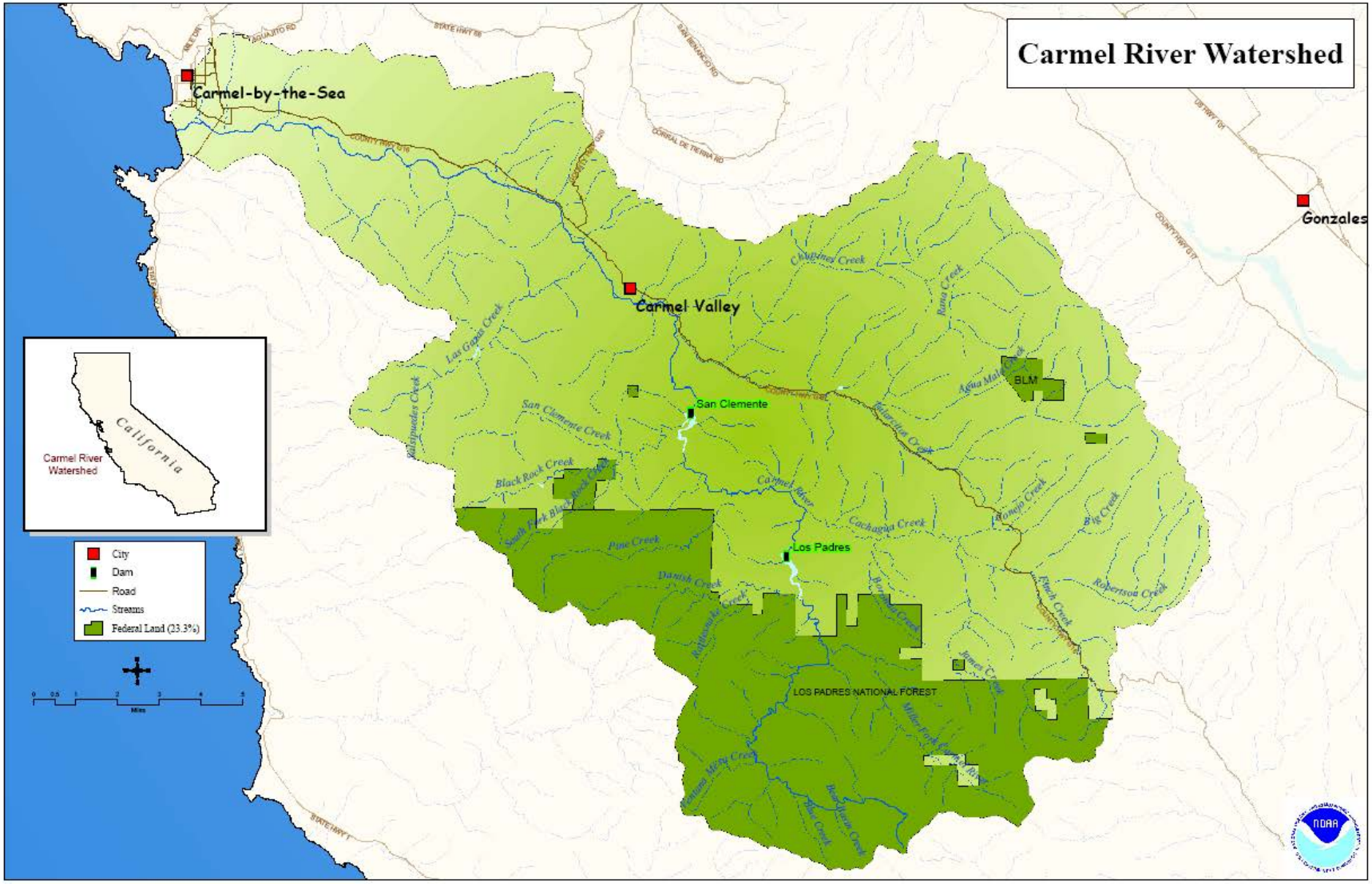

Figure 10-2. Federal and Non-Federal Land ownership within the Carmel River Watershed.

10.3 CURRENT WATERSHED CONDITIONS

Watershed conditions in this BPG region were assessed for the Carmel River watershed. A total of 30 indicators were used in the CAP Workbook analysis for this BPG. This analysis rated overall habitat conditions for anadromous *O. mykiss* in the Carmel River watershed as "Fair." Approximately 33 percent of the indicators were impaired (fair condition) or severely impaired (poor condition) and these indicators repeatedly focused on lack of surface flows in the mainstem caused by water management activities (*i.e.,* dams, surface water diversions, and excessive pumping of groundwater). (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b; see also, March 2012, Monterey Peninsula Water Management District, 2000-2011, 1983, Casagrande 2006, Casagrande and Watson 2003, California Department of Fish and Game 2005, Monterey Peninsula Water Management District and Carmel River Watershed Conservancy 2004, Carmel River Conservancy 2004, Stephenson and Calcarone 1999, Dettman 1987, 1986, Kondolf 1986, Snider 1983, California Department of Water Resources 1978.)

The mainstem contains suitable spawning habitat and functions as the conduit connecting the ocean and estuary to even more extensive spawning habitat in the upper watershed. However, San Clemente and Los Padres dams (while equipped with fish passage facilities) impede access to spawning and rearing habitat in at least 50 percent of the Carmel River watershed. Native non-anadromous *O. mykiss* populations persist in the mainstem and most of the tributaries above these dams. Additionally, a significant portion of the lower Carmel River below San Clemente Dam has been altered by bank protection for flood control purposes, thus adversely affecting steelhead habitats.

Carmel River – Residential Encroachment

Another aspect of the Carmel River watershed that received low ratings was the estuary. While the existing estuary has undergone substantial restoration and still contains valuable rearing habitat, at least 33% of the original estuary has been eliminated due to encroachment from residential development, transportation corridors (Highway 1), and recreational development (Carmel Beach State Park). (See Anderson *et al*. 2008, California Department of Fish and Game 2008, Carmel River Coalition 2007, Perry *et al.* 2007, Casagrande 2006, Casagrande and Watson 2003, Larson *et al.* 2006, Watson and Casagrande 2004, Hagar 2003, Alley Associates 1997, Kitting 1990, Dettman 1984.)

Carmel River Estuary – Artificial Breaching

10.4 THREATS AND THREAT SOURCES

Information identified in the CAP Workbooks on habitat and land-use indicators for the Carmel River Basin BPG was supplemented by additional information developed since the preparation of the CAP Workbooks and incorporated into the threat assessment. However, the underlying threat sources that determined the poor to very poor conditions of approximately one-third of those indicators repeatedly pointed to a limited number of anthropogenic causes, including: passage barriers caused by excessive surface and groundwater diversions; passage impediments caused by dams; loss or degradation of spawning substrates below San Clemente Dam due to water management practices, including substantial groundwater use for golf course irrigation; urban development, and associated levee construction that has significantly reduced estuarine habitats and constricted the lower floodplain of the river; and artificial breaching of the estuary sandbar to alleviate flooding of adjacent residential development.

San Clemente Dam

A pervasive threat to anadromous *O. mykiss* throughout the Carmel River BPG region are impediments to upstream and downstream fish passage, either in the form of dams and surface water diversions, or excessive groundwater extraction that creates dry stream reaches (Table 10-2), and connectivity with the Carmel River Estuary. Several miles of the mainstem Carmel River below San Clemente Dam that would otherwise have perennial surface flows frequently dry up or are reduced to isolated pools by late spring and early summer due to a combination of reduced runoff and surface and subsurface water withdrawals. As a result, an annual fish rescue and relocation efforts is made to deal with this situation on an interim basis (with fish reared and subsequently released from the Sleepy Hallow rearing facility located downstream of the San Clemente Dam and operated by the Monterey Peninsula Water Management District. Spawning habitat in the mainstem below San Clemente Dam has been degraded by water releases from the dam, contributing to increasing bank erosion and armoring. The Los Padres Dam has also constrained the natural movement of steelhead, both upstream migrating adults and downstream emigrating juveniles (Capelli 2007, Entrix 2006, Raines and Carella 2002, Monterey Peninsula Water Management District 2000, R2 Resource Consultants 2000, Stephenson and Calcarone 1999, Alley Associates 1998, 1996, 1992, Dettman 1993, 1989).

Los Padres Dam

Surface and groundwater extractions artificially modify the pattern of sandbar formation and natural breaching at the estuary. The sandbar is also breached artificially for flood control, which causes premature draining of the estuary; these artificial breachings can result in the loss of important juvenile steelhead rearing habitat, as

well as the flushing of rearing juveniles to the ocean (California Department of Parks and Recreation 2008, Watson and Casagrande 2004, National Marine Fisheries Service 2002, Dettman 1984, U.S. Fish and Wildlife Service 1980).

Carmel River Estuary.

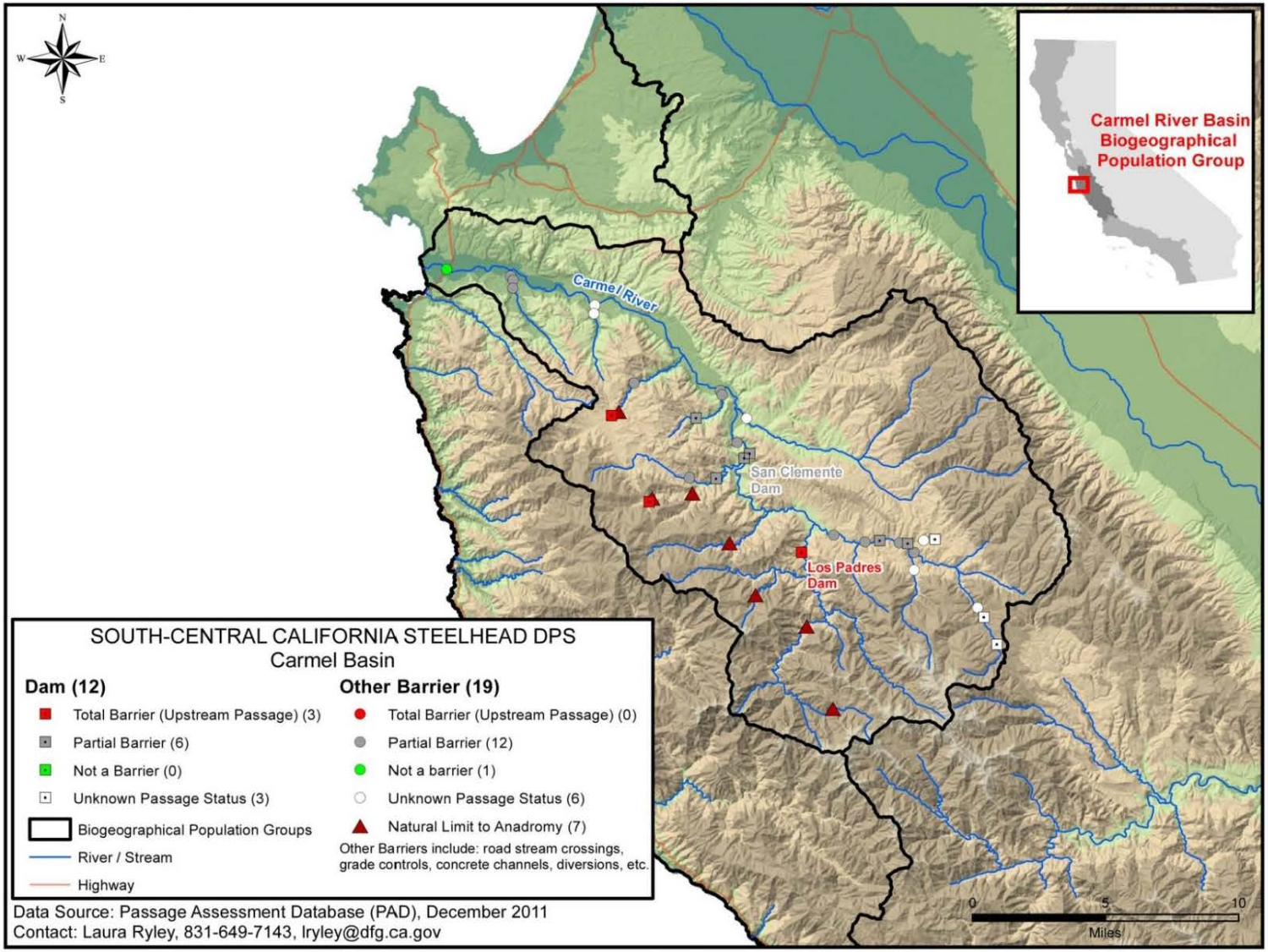

Figure 10-4. Major Fish Passage Barriers, Carmel River Basin BPG.

Table 10-2. Threat source rankings in the Carmel River Basin BPG region (see CAP Workbooks for details).

THREAT SOURCES*	WATERSHED
	Carmel River
Dams and Surface Water Diversions	
Groundwater Extraction	
Urban Development	
Levees and Channelization	
Culverts and Road Crossings (Other Passage Barriers)	
Recreational Facilities	

Key: Threat cell colors represent threat rating from CAP Workbook: Red = Very High threat; Yellow = high threat; Light green = Medium threat; Dark green = Low threat

**Note Agricultural development was not identified during the CAP Workbook analyses as one of the top five threats in this watershed, but agricultural development in the middle reaches of the Carmel River, and with some tributaries could be a significant threat to these population.*

10.5 SUMMARY

Dams and diversions (including groundwater extractions) on the Carmel River have had the most severe adverse impacts on steelhead populations in this BPG by reducing access to upstream spawning and rearing habitats and altering the magnitude, and timing of flows necessary for immigration of adults and emigration of juveniles. Urban and agricultural developments within the Carmel River watershed are also significant threats. For example, residential development around the estuary and along some reaches of the lower mainstem has encroached on and degraded estuarine and riparian habitats. Generally, road density, population density, and fire frequency are relatively low; however these factors can be expected to increase in the future.

Because the mainstem of the Carmel River is the conduit that connects upstream spawning and rearing habitat with the ocean, recovery actions in this watershed should focus on reducing the severity of anthropogenic impacts stemming from the construction and operation of dams (*e.g.,* San Clemente and Los Padres Dams) and groundwater extractions along the mainstem in order to promote connectivity between the ocean and estuarine habitats, as well as to maintain spawning and rearing habitat in the mainstem itself. Additionally, degraded estuarine conditions stemming from filling, artificial sandbar manipulation, and both point and non-point waste discharges, should be further evaluated and addressed. Table 10-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG.

The threat sources discussed in this chapter are the focus of a variety of recovery actions to address specific stresses associated with these threats. Spatial and temporal data acquired on specific indicators associated with sources of threats or stresses, such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Carmel River Basin BPG. Recovery Action Table 10-4 below ranks and describes proposed recovery actions in the Carmel River Basin BPG including the estimated cost for implementing such actions in five year increments, and where applicable extended out to 100 years, though many of the recovery actions can and should be achieved within a shorter period (Hunt & Associates 2008a 2008b, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

Table 10-3. Critical recovery actions for Core 1 populations within the Carmel River Basin BPG.

POPULATION	CRITICAL RECOVERY ACTIONS
Carmel River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, from San Clemente and Los Padres Dams to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove San Clemente, Los Padres, and Old Carmel River Dams 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.

South-Central California Coast Steelhead DPS Recovery Action Tables Identification Key, Carmel River Basin BPG (Table 10-4).

Recovery Action Number Key: XXXX – SCCCS – 1.2	
XXXX	Watershed
SCCCS	Species Identifier – South-Central California Steelhead
1	Threat Source
2	Action Identity Number
Action Rank	
A	Action addresses the first listing factor regarding the destruction or curtailment of the species' habitat
B	Action addresses one of the other four listing factors

XXXX ID Table	
Car	Carmel River

Threat Source Legend	
1	Agricultural Development
2	Agricultural Effluents
3	Culverts and Road Crossings (Passage Barriers)
4	Dams and Surface Water Diversions
5	Flood Control Maintenance
6	Groundwater Extraction
7	Levees and Channelization
8	Mining and Quarrying
9	Non-Native Species
10	Recreational Facilities
11	Roads
12	Upslope/Upstream Activities
13	Urban Development
14	Urban Effluents
15	Wildfires

See Chapter 8, Table 8-1 for Detailed Description of Recovery Actions. See Appendix E for discussion of recovery action cost estimates.

Table 10-4. South-Central California Steelhead DPS Recovery Action Table for the Carmel River Watershed (Carmel River Basin BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Carmel River												
Car-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, MC, MPWMD, CRWC	Agricultural Development	1, 4, 5	2B	20	0	0	0	0	0	0
Car-SCCCS-1.2	Manage agricultural development and restore riparian zone	NRCS, BLM,NMFS, MC, MPWMD, CRWC, CCON, CDFG, CRA, CRSA, CRWC, CVPOA	Agricultural Development	1, 4, 5	2B	5	0	0	0	0	0	0
Car-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM,NMFS, MC, MPWMD, CRWC, CCON, CDFG, CRA, CRSA, CRWC, CVPOA	Agricultural Effluents	1, 4, 5	2B	100	0	0	0	0	0	0
Car-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCON, MPWMD, CAWC, CRLC, CRSA, CRWC, CRWCO	Culverts and Road Crossings (Passage Barriers)	1, 4, 5	1B	5	96690	0	0	0	0	96690
Car-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, CDFG, CCON, MPWMD, CAWC, CRLC, CRSA, CRWC, CRWCO	Culverts and Road Crossings (Passage Barriers)	1, 4, 5	1B	20	TBD	TBD	TBD	TBD	TBD	TBD
Car-SCCCS-4.1	Develop and implement water management plan for dam operations	NMFS, CDFG, MPWMD, CAWC, CRA, CRWC	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Car-SCCCS-4.2	Develop and implement water management	NMFS, CDFG, MPWMD, CAWC, CRA, CRWC	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	plan for diversion operations											
Car-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, CDFG, MPWMD, CAWC, CRA, CRWC	Dams and Surface* Water Diversions *Reflects only the cost of the removal of San Clemente Dam; the removal of Los Padres and Old Carmel River Dams have not been estimated.	1, 3, 4	1A	5	84000000	0	0	0	0	84000000
Car-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, FEMA, NMFS, CDFG, MC, COC, MCPWP, MPWMD, CRLC, CRSA, CRWC, CRWCO, CVPOA	Flood Control Maintenance	1, 3, 4	2A	100	0	0	0	0	0	0
Car-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	MC, MCWRA, MPWMD, NMFS, CDFG, CAWC, CRA, COC, PBCSD, CRLC, CRSA, CRWC, CRWCO	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
Car-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	MC, MCWRA, MPWMD, NMFS, CDFG, CAWC, CRA, COC, PBCSD, CRLC, CRSA, CRWC, CRWCO	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
Car-SCCCS-7.1	Develop and implement a plan to restore natural channel features	NRCS, FEMA, NMFS, CDFG, CRA, COC, CRSA, CRWC, CRWCO, CVPOAMCPA, MCWRA,MPWMD, MCUSA	Levees and Channelization	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500
Car-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or	NRSC, FEMA, NMFS, CDFG, CRA, CRSA, CRWC, CRWCO, CVPOAMCPA,	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	minimize herbicide use near levees	MCWRA,MPWMD, MCUSA										
Car-SCCC S-7.3	Develop and implement stream bank and riparian corridor restoration plan	NRSC, FEMA, NMFS, CDFG, CRA, COC, CRSA, CRWC, CRWCO, CVPOAMCPA, MCWRA,MPWMD, MCUSA	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
Car-SCCC S-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CRA, CRSA, CRWC, CRWCO	Non-Native Species	1, 3, 5	1B	100	0	0	0	0	0	0
Car-SCCC S-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CRA, CRSA, CRWC, CRWCO	Non-Native Species	1, 3, 5	1B	100	0	0	0	0	0	0
Car-SCCC S-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CRA, CRSA, CRWC, CRWCO	Non-Native Species	1, 3, 5	1B	20	76140	76140	76140	76140	0	304560
Car-SCCC S-10.1	Review and modify development and management plans for recreational areas and national forests	CDPR, CDFG, USFS, NMFS, MC, CRA, COC, CRLC, CRSA, CRWC, CRWCO, MBNMS, MRPD	Recreational Facilities	1, 2, 3, 4, 5	1B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	(*e.g.,* the Carmel State Beach Management Plan)											
Car-SCCCS-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFG, USFS, NMFS, MC, CRA, COC, CRLC, CRSA, CRWC, CRWCO, MBNMS, MRPD	Recreational Facilities	1, 2, 3, 4, 5	1B	20	76140	76140	76140	76140	0	304560
Car-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFG, AMBAG, CRA, COC, CRSA, CRWC, CRWCO, CWPOA	Roads	1, 4	2B	20	0	0	0	0	0	0
Car-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, CDOT, MC,MCPWD, NMFS, CDPR, CDFG, AMBAG, CRA, COC, CRSA, CRWC, CRWCO, CWPOA	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
Car-SCCCS-11.3	Develop and implement plan to remove or reduce approach fill f or railroad line and roads	USDOT, CDOT, MC,MCPWD, NMFS, CDPR, CDFG, AMBAG, CRA, COC, CRSA, CRWC, CRWCO, CWPOA	Roads	1, 4	2B	20	0	0	0	0	0	0
Car-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFG, AMBAG TWI	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1876000	0	0	0	0	1876000

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Car-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, COC, NMFS, CDFG, MCPWD, CRA, CRSA, CRWC, CVPOA	Upslope/Upstream Activities	1, 2, 3, 4, 5	1B	5	62400	0	0	0	0	62400
Car-SCCC S-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, MC, NMFS, CDFG, AMBAG, MCPWD, COC, CRA, CRSA, CRWC, CVPOA	Urban Development	1, 4, 5	1B	5	62400	0	0	0	0	62400
Car-SCCC S-13.2	Retrofit storm drains in developed areas	RWQCB, MC, NMFS, CDFG, AMBAG, MCPWD, COC, CRA, CRSA, CRWC, CVPOA	Urban Development	1, 4, 5	1B	20	0	0	0	0	0	0
Car-SCCC S-14.1	Review California Regional Water Quality Control Board s Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, MCPWD, CRA, COC, CRLC, CRSA, CRWCO, CVPOA, PBCSD, MC, MCWRA, MPWMD	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0
Car-SCCC S-14.2	Review, assess and modify NPDES wastewater discharge permits (*e.g.,* Carmel Area Wastewater Treatment Facility)	RWQCD, SWRCB, NMFS, CDFG, CAWD, CRA, COC,CRLC, CRSA, CRWCO, CVPOA, PBCSD, MC, MCWRA, MPWMD	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0
Car-SCCC S-15.1	Develop and implement an integrated wildland fire and hazardous fuels management	USFS, USFWS, CDF&FP, MC, NMFS, CDFG, MPWMD, MRPD, CRA, CRSA, CRWC, CRWCO	Wildfires	1,4,5	1B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	plan											

11. Big Sur Coast Biogeographic Population Group

"Assessment at the group level indicates a priority for securing inland populations in southern Coast Ranges and Transverse Ranges, and a need to maintain not just the fluvial-anadromous life-history form, but also lagoon-anadromous and freshwater-resident forms in each population."

NOAA Fisheries Technical Recovery Team
Viability Criteria for South-Central and Southern California Steelhead, 2007

11.1 LOCATION AND PHYSICAL CHARACTERISTICS

The Big Sur Coast BPG consists of seven small watersheds that drain the steep coastal slopes of the northern Santa Lucia Range. This region extends approximately 60 miles along a sparsely populated section of coastal Monterey County from the Monterey Peninsula southward almost to the San Luis Obispo County line. From north to south, these watersheds are: San Jose Creek, Garrapata Creek, Bixby Creek, Little Sur River, Big Sur River, Willow Creek, and Salmon Creek (Figure 11-1).

The Big Sur Coast BPG resembles the Conception Coast BPG in Santa Barbara County and the Santa Monica Mountains BPG in Ventura and Los Angeles counties in that its component watersheds are, with one or two exceptions, small, steep, and have small total stream lengths. Although average annual precipitation shows little spatial variation across the component watersheds, total seasonal rainfall in this region is highly variable from year to year, depending on the intensity and duration of Pacific storms.

Big Sur Coast

In general, the higher elevations receive greater amounts of precipitation, and persistent spring and summer fog is characteristic of this region. All of the watercourses in this BPG are perennial (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

11.2 LAND USE

Table 11-1 summarizes land use and population density in the Big Sur Coast BPG region. This BPG region supports, by far, the lowest total human population of any other BPG region and is highly buffered from urban areas by extensive undeveloped open space and rural lands. Average human population density averages about 4 persons per square mile (Table 11-1).

The closest population centers are the small towns of Carmel near the north end and Cambria near the south end of the BPG region.

Big Sur River

There are no major cities or towns within this BPG. There is a strong gradient of increasing public ownership of watershed lands, from less than 1 percent in the San Jose Creek watershed in the north to over 98% in the Salmon Creek watershed in the south. Most of the federal lands are in the Los Padres National Forest. Small parcels of National Recreation Area lands occur along the immediate coast. The Los Padres National Forest encompasses several federally designated wilderness areas, such as Ventana and Silver Peak Wilderness Areas. Additionally, the Big Sur River, including the North and South Forks, is a federally designated Wild River. There are several State and County parks along the coast in this region, but some of the larger state parks, such as Andrew Molera and Pfeiffer-Big Sur in the Big Sur River watershed, extend well inland.

Little Sur River

Urban and agricultural conversion of land in these watersheds lands is correspondingly low, with the overwhelming majority of watershed lands being open space (Table 11-1). There are no major dams in this region, though there are seasonal dams in some drainages that may affect anadromous *O. mykiss*, particularly the instream movement of juveniles (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Stephenson and Calcarone 1999, California Department of Water Resources 1978).

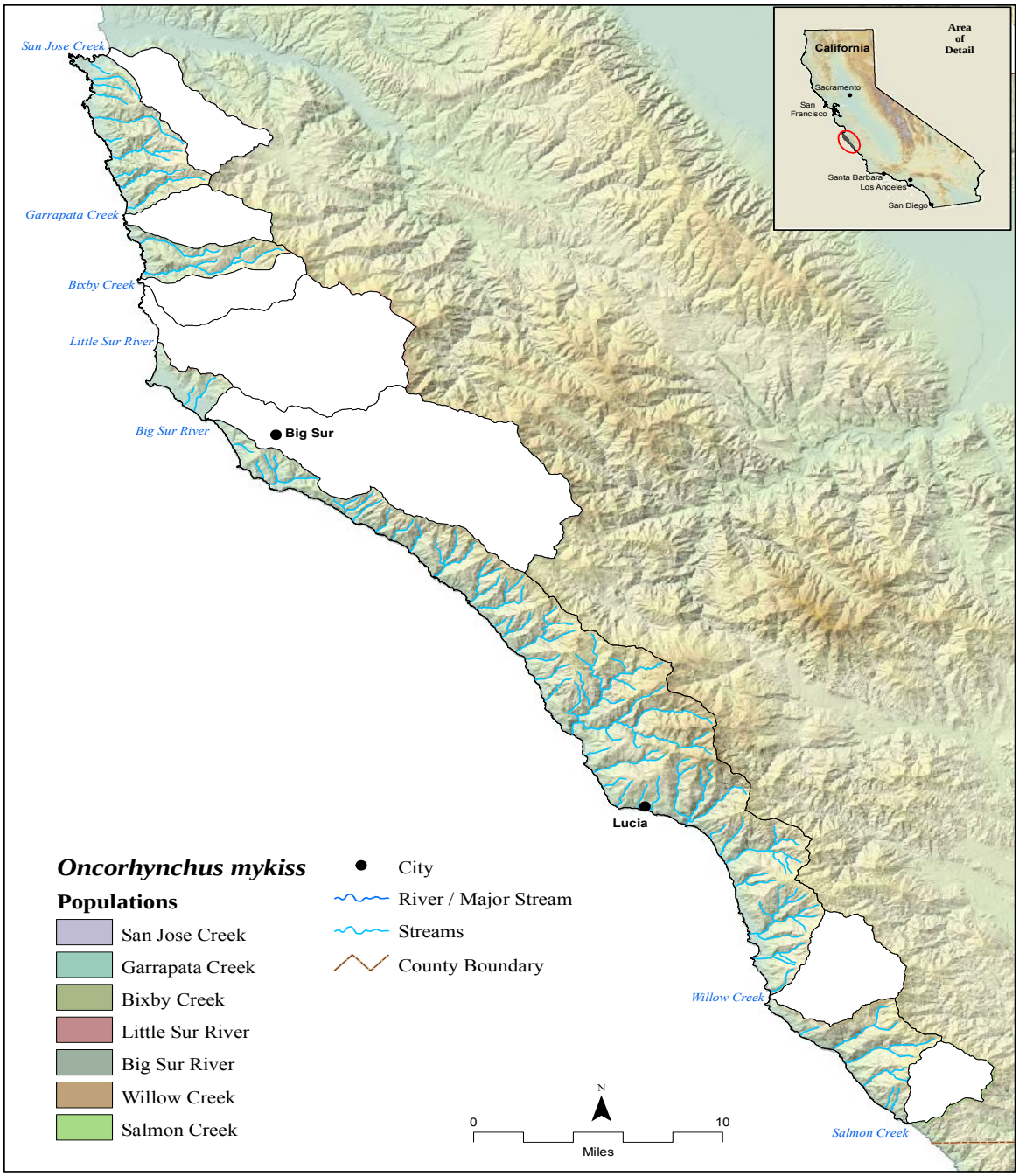

Figure 11-1. The Big Sur Coast BPG region. Seven populations/watersheds were analyzed in this region.

Table 11-1. Physical and Land-Use Characteristics of Watersheds in the Big Sur Coast BPG region.

PHYSICAL CHARACTERISTICS						**LAND USE**			
WATERSHEDS (north to south)	**Area** (acres)[1]	**Area** (sq.miles)[1]	**Stream Length**[2] (miles)	**Ave. Ann. Rainfall**[3] (inches)	**Total Human Population**[4]	**Public Ownership***	**Urban Area**[5]	**Agriculture/ Barren**[5]	**Open Space**[5]
San Jose Creek	8,826	14	23	20.3	41	0.1%	0.2%	0.1%	> 99%
Garrapata Creek	6,925	11	16	20.5	122	12%**	0%	0%	100%
Bixby Creek	7,218	11	15	20.8	27	27%	0%	0%	100%
Little Sur River	26,541	41	64	20.8	60	63%	0.2%	< 0.1%	> 99%
Big Sur River	37,374	58	92	20.8	341	86%	0.7%	< 0.1%	> 99%
Willow Creek	10,412	16	26	18.5	27	95%	0%	0%	100%
Salmon Creek	5,406	8	12	19.5	2	98%	0%	0%	100%
TOTAL or AVERAGE	**102,702**	**159**	**248**	**20.2**	**618**	**54%**	**< 0.2%**	**< 0.1%**	**> 99%**

[1] From: CDFFP CalWater 2.2 Watershed delineation, 1999 (www.ca.nrcs.usda.gov/features/calwater/)
[2] From: CDFG 1:1,000,000 Routed stream network, 2003 (www.calfish.org/)
[3] From: USGS Hydrologic landscape regions of the U.S., 2003 (1 km grid cells)
[4] From: CDFFP Census 2010 block data (migrated), CalFire FRAP (http://frap.cdf.ca.gov/data/frapgisdata/select.asp)
[5] From: CDFFP Multi-source land cover data (v02_2), 2002 (100 m grid cells) (http://frap.cdf.ca.gov/data/frapgisdata/select.asp)
** Includes National Forest lands and State Recreation Areas, does not include State and County Parks (from: http://old.casil.ucdavis.edu/casil/gis.ca.gov/teale/govtowna/)*
*** 68% of the watershed is owned by the State, Land Trust, or has conservation easement restrictions on land use.*

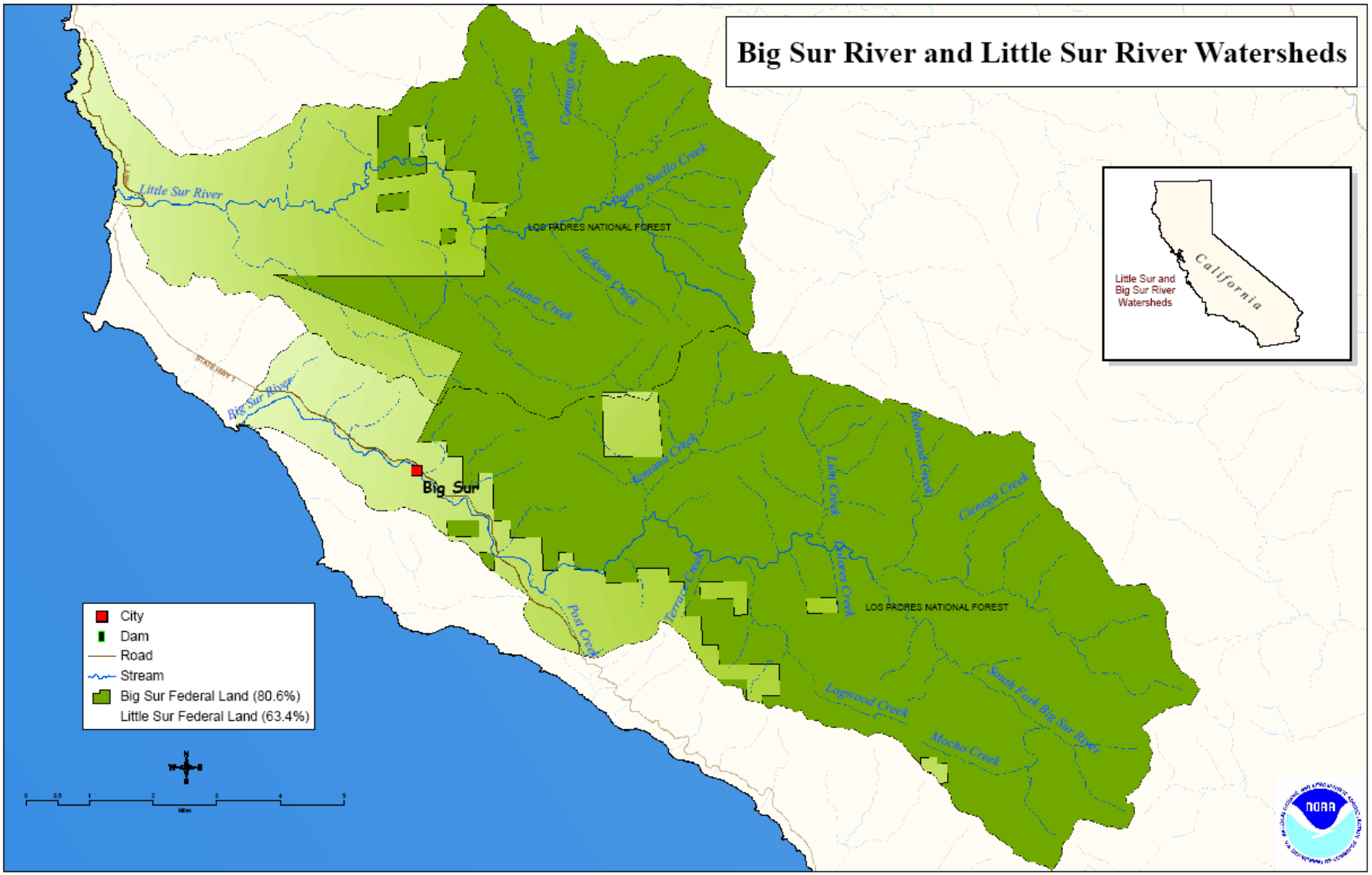

Figure 11-2. Federal and Non-Federal Land Ownership within the Big and Little Sur Watersheds.

11.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for the seven major drainages in the Big Sur Coast BPG region. Instream, riparian, and upland habitat conditions in the watersheds in this region are collectively rated the highest of any of the BPG regions by the CAP Workbook analyses. The CAP Workbooks rated overall habitat conditions for steelhead as "Fair" in the San Jose Creek watershed, "Good" in the Garrapata Creek, Big Sur River, and Salmon Creek watersheds, and "Very Good" in the Bixby Creek, Little Sur River, and Willow Creek watersheds. However, Garrapata is impacted by logjams which impede fish passage, and elevated levels of fine sediments resulting from roads. The Little Sur River Estuary is the most intact estuary within the SCCCS Recovery Planning Area – the result of the Highway 1 alignment upstream of the estuary (Garrapata Creek Watershed Community Council 2006, Smith *et al.* 2006, 2005, Casagrande and Smith 2005, Nedeff 2005, 2004, Pacific Watershed Associates 2003, Kittleson Environmental Consultants 2002, Rathbun et al. 1991).

Little Sur River Estuary

Land-use activities that negatively affect these ratings are most pronounced in watersheds that are mostly under private ownership. For example, the San Jose Creek, Garrapata Creek, and Bixby Creek watersheds are degraded by groundwater and surface water diversions, increased sedimentation from old logging roads, and fish-passage barriers created by log or debris jams associated with past logging activities, and in the case of San Jose Creek, the loss and degradation of estuarine habitat as the result of the design and alignment of U.S. Highway 1 (Nelson *et al.* 2006a, 2006b, Nelson 2005, Hagar Environmental Science 2002.

San Jose Creek Estuary

The Big Sur River and Salmon Creek have natural barriers that block anadromous *O. mykiss* passage to the middle and upper portions of these watersheds. While this limits the amount of accessible spawning and rearing habitat, particularly in Salmon Creek, the most significant adverse impacts are to the Big Sur River stemming from water withdrawals in the lower reaches, and both public and private recreational development within the vicinity of U.S. Highway 1

.

Salmon Creek

Increased fire frequency in these watersheds was rated as a severe threat because of potential sedimentation and various other fire-related impacts to instream and riparian habitats. In general, however, the six watersheds south of San Jose Creek provide excellent spawning and rearing habitat (Watson *et al*. 2008, Denise Duffy and Associates 2003, Kittleson Environmental Consultants, Denise Duffy and Associates and Fall Creek Engineering 2002, Collin 1998, Rischbieter 1990a).

Willow Creek

11.4 THREATS AND THREAT SOURCES

Information identified in the CAP Workbooks on habitat and land-use indicators for the Big Sur Coast BPG was supplemented by additional information developed since the preparation of the CAP Workbooks and incorporated into the threat assessment. The number of threats identified in the CAP Workbook analysis in the Big Sur Coast BPG region is very low compared to other BPG regions, ranging from three in the Bixby Creek watershed to eleven in the San Jose Creek watershed; however, additional information developed since the preparation of the CAP has also been incorporated into the threat assessment. These relatively low numbers of threats reflect the low human population density and fewer associated land-use impacts in this portion of the SCCCS Recovery Planning Area. Aside from San Jose Creek watershed, the most pervasive threats stem from roads (as a source of sedimentation and barriers to fish passage), wildfires, and other fish passage barriers (e.g., periodic landslides), and groundwater extractions (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

Little Sur River – Road Cut

On-going restoration and re-vegetation of eroded slopes and decommissioned logging roads in the Garrapata Creek watershed should

eventually reduce or eliminate this threat source and improve habitat conditions for steelhead. Land-use activities in the mostly privately-owned San Jose Creek watershed pose a number of problems. Surface water diversions and groundwater extraction in the mainstem of San Jose Creek severely impair instream habitat quality and quantity for anadromous *O. mykiss*. Such diversions create passage barriers (*i.e.,* dry stream reaches), and can exacerbate poor water quality under extremely low-flow conditions. Higher road density in this watershed serves to further degrade water quality through input of sediment and other sources of pollution arising from road surfaces (Watson *et al*. 2008, Garrapata Creek Watershed Council 2006, Nelson *et al*. 2006a, 2006b,, Nedeff 2004, 2005, Ford 2004).

The persistence of anadromous *O. mykiss* in the Salmon Creek watershed is potentially threatened by a large waterfall that sets the natural limit of anadromy is less than a mile above the mouth of the creek. Mainstem Salmon Creek between the ocean and the Highway 1 culvert provides excellent spawning and rearing habitat for anadromous *O. mykiss* (although that culvert is also barrier to upstream fish passage under low-flow conditions).

Salmon Creek

The three principal sources of threats to individual steelhead populations in the Big Sur Coast BPG are passage barriers created by culverts, road crossings, and periodic landslides; impediments to migration and degradation of spawning and rearing habitats as a result of groundwater extraction, and surface water diversions; and non-point pollution, including sedimentation resulting road cuts, including abandoned logging roads. Wildfires and non-native species, particularly plants, are also continuing or potential pervasive threats within the Big Sur Coast BPG. However, CAP Workbook Analysis of the Bixby Creek watershed produced only three threats (Table 11-2). The severity of these threats compared to similar threat levels in other BPGs in the SCCCS Recovery Planning Area is generally low (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

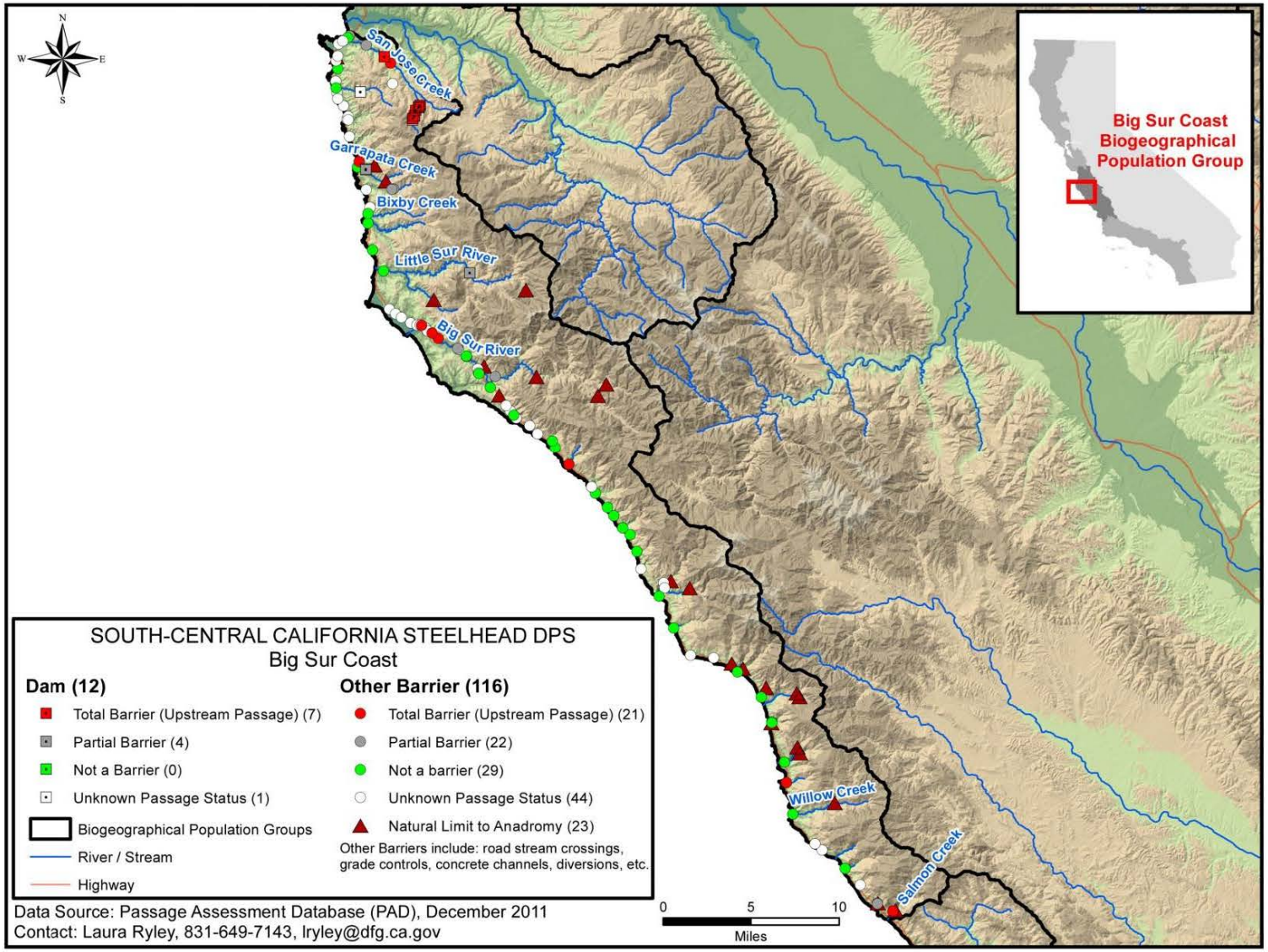

Figure 11-4. Major Fish Passage Barrier, Big Sur Coast BPG.

Table 11-2. Threat source rankings in the component watersheds of the Big Sur Coast BPG region (see CAP Workbook for details).

Big Sur Coast BPG Component Watershed (north to south)							
THREAT SOURCES	San Jose Creek	Garrapata Creek	Bixby Creek	Little Sur River*	Big Sur River	Willow Creek	Salmon Creek
Culverts and Road Crossings (Other Passage Barriers							
Roads							
Non-Point Pollution							
Groundwater Extraction							
Recreational Facilities							
Wildfires							
Dams and Surface Water Diversions							
Non-Native Species							

Key: Threat cell colors represent threat rating from CAP Workbook: Red = Very High threat; Yellow = High threat; Light green = Medium threat; Dark green = Low threat

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11.5 SUMMARY

The Big Sur Coast BPG contains some of the least altered watersheds within any of the four BPG regions in the SCCCS Recovery Planning Area. In particular, the Bixby Creek, Little Sur River, Big Sur River, Willow Creek, and Salmon Creek watersheds are some of the best preserved, though there are significant developments along the middle portions of the Little Sur and lower reaches of the Big Sur Rivers. With the exception of San Jose Creek and Garrapata Creek, the majority of threats in the watersheds in the Big Sur Coast BPG are rated as low. Only three medium-severity threat sources were identified for the relatively undeveloped Bixby Creek watersheds. However, these conditions could change in the future because some of these watersheds are largely under private ownership, are all traversed by Highway 1, and all support low to moderately intense livestock ranching operations. Additionally, natural wildfires remain a persist threat throughout the Big Sur Coast BPG.

Increased residential and recreational development within several of these watersheds, including higher road densities, could significantly alter natural fire regimes in the Big Sur Coast BPG by allowing greater human access to portions of these watersheds. Increased fire frequency can increase slope erosion and sediment input to streams, resulting in long-term changes to substrate composition, embeddedness, water quality (*e.g.,* turbidity), and water temperature (loss of riparian canopy cover).

Improving one or more of the moderate threats that adversely affect anadromous *O. mykiss* habitat in the Bixby Creek, Little Sur River, Big Sur River, Willow Creek, and Salmon Creek watershed (*e.g.,* road crossings and erosion control) could reduce or eliminate threats to anadromous *O. mykiss* habitats in these watersheds. Recovery actions to address the severe to very severe sedimentation impacts from existing and abandoned roads and fish-passage impediments in the San Jose Creek and Garrapata Creek watersheds will require multiple, long-term, measures related to water management and land-use practices, including agricultural and residential development and related road development. Additionally, the restoration of the San Jose estuary, which has largely been eliminated as a result of the construction of Highway 1, will require removal of fill and replacement of the existing culvert with a free-spanning road crossing. Table 11-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG.

The threat sources discussed in this chapter should be the focus of a variety of recovery actions to address specific stresses associated with these threats. Spatial and temporal data acquired on specific indicators associated with sources of threats or stresses, such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Big Sur Coast BPG. Tables 11-4 through 11-10 below rank and describe proposed recovery actions for each sub-watershed in the Big Sur Coast BPG including the estimated cost for implementing such actions in five year increments, and where applicable extended out to 100 years, though many of the recovery actions can and should be achieved within a shorter period (Hunt & Associates 2008a 2008b, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

Table 11-3. Critical recovery actions for Core 1 populations within the Big Sur Coast BPG.

POPULATION	CRITICAL RECOVERY ACTIONS
San Jose Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage barriers 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. Identify sources of sediment and develop a comprehensive, watershed-wide sediment management plan. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
Little Sur River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage barriers 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. Manage roads to minimize sedimentation of spawning and rearing habitat.
Big Sur River	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, to provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage barriers 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.

South-Central California Coast Steelhead DPS Recovery Action Tables Identification Key, Big Sur Coast BPG (Tables 11-4 to 11-10).

Recovery Action Number Key: XXXX – SCCCS – 1.2	
XXXX	Watershed
SCCCS	Species Identifier – South Central California Steelhead
1	Threat Source
2	Action Identity Number

Action Rank	
A	Action addresses the first listing factor regarding the destruction or curtailment of the species' habitat
B	Action addresses one of the other four listing factors

XXXX ID Table	
SJC	San Jose Creek
Gar	Garrapata Creek
Bix	Bixby Creek
LS	Little Sur River
BS	Big Sur River
WC	Willow Creek
SC	Salmon Creek

Threat Source Legend	
1	Agricultural Development
2	Agricultural Effluents
3	Culverts and Road Crossings (Passage Barriers)
4	Dams and Surface Water Diversions
5	Flood Control Maintenance
6	Groundwater Extraction
7	Levees and Channelization
8	Mining and Quarrying
9	Non-Native Species
10	Recreational Facilities
11	Roads
12	Upslope/Upstream Activities
13	Urban Development
14	Urban Effluents
15	Wildfires

See Chapter 8, Table 8-1 for Detailed Description of Recovery Actions. See Appendix E for discussion of recovery action cost estimates.

Table 11-4. South-Central California Steelhead DPS Recovery Action Table for the San Jose Creek Watershed (Big Sur Coast BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
San Jose Creek												
SJC-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, CCON, MC, RCDMC, MPWMD, TWI, TBSLT, VWA	Agricultural Development	1,3, 4	2B	20	0	0	0	0	0	0
SJC-SCCCS-1.2	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM,NMFS, MC, RCDMC, MPWMD, CCCON, CDFG, TWI, TBSLT, VWA	Agricultural Effluents	1,3, 4	2B	100	0	0	0	0	0	0
SJC-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, MPWMD, TWI, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2B	5	96690	0	0	0	0	96690
SJC-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, CDFG, CCCON, MPWMD, TWI, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	1A	5	0	0	0	0	0	0
SJC-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFG, CCCON, MPWMD, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
SJC-SCCCS-4.2	Provide fish passage around dams and diversions	NMFS, CDFG, CCCON, MPWMD, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
SJC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	MC, MCWRA, MPWMD, NMFS, USGS, CDFG, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SJC-SCCC S-6.2	Develop and implement a groundwater monitoring and management program	MC, MCWRA, MPWMD, NMFS, USGS, CDFG, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
SJC-SCCC S-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, TWI, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
SJC-SCCC S-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, TWI, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
SJC-SCCC S-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, TWI, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
SJC-SCCC S-10.1	Review and modify development and management plans for recreational areas and national forest (*e.g.*, Santa Lucia Preserve Management Plan)	CDPR, CDFG,, NMFS, MC, CRA, MBNMS, MRPD, TWI, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
SJC-SCCC S-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFG,, NMFS, MC, CRA, MBNMS, MRPD, TWI	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
SJC-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, CD, TBSLT, VWA OT, MC, MCPWD, NMFS, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1,4	1A	20	0	0	0	0	0	0
SJC-SCCC S-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFG, AMBAG	Roads	1,4	1A	20	32260	32260	32260	32260	0	129040

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		TWI, TBSLT, VWA										
SJC-SCCCS-11.3	Develop and implement a plan to remove or reduce approach-fill for railroad lines and roads	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1,4	1B	20	0	0	0	0	0	0
SJC-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFG, AMBAG TW, TBSLT, VWA I	Upslope/Upstream Activities	1, 4, 5	1A	5	670000	0	0	0	0	670000
SJC-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, COC, NMFS, CDFG, MCPWD,TWI, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
SJC-SCCCS-13.1	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	CCCOM, MC, NMFS, CDFG, AMBAG, MCPWD, TWI, TBSLT, VWA	Urban Development	1, 4, 5	2B	5	398000	0	0	0	0	398000
SJC-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, MCPWD, TWI, TBSLT, VWA	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
SJC-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, MCPWD, TWI, TBSLT, VWA	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
SJC-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, MC, NMFS, CDFG,	Wildfires	1, 4, 5	2B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		MPWMD, MRPD, TBSLT, VWA										

Table 11-5. South-Central California Steelhead DPS Recovery Action Table for the Garrapata Creek Watershed (Big Sur Coast BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Garrapata Creek												
Gar-SCCC S-3.1	Conduct watershed-wide fish passage barrier assessment (or periodically update)	NMFS, CDFG, CCCON, MC, TWI, GCWC, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	1A	5	96690	0	0	0	0	96690
Gar-SCCC S-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed (*e.g.,* Garrapata Creek Watershed Barrier Assessment, 2005)	NMFS, CDFG, CCCON, MC, TWI, GCWC, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	1A	5	0	0	0	0	0	0
Gar-SCCC S-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFG, CCON. MC, GCWC, TBSLT, VWA	Dams and Surface Water Diversions	1, 3 4	1A	5	0	0	0	0	0	0
Gar-SCCC S-4.2	Provide fish passage around any future dams and diversions	NMFS, USFS, CDFG, CCON. MC, GCWC, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
Gar-SCCC S-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USGS, CDFG, CCON, MC, GCWC, TBSLT, VWA	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
Gar-SCCC S-6.2	Develop and implement a groundwater monitoring and management program	NMFS, USGS, CDFG, CCON. MC, GCWC	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
Gar-SCCC S-9.1	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, GCWC, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
Gar-SCCC S-9.2	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, GCWC, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Gar-SCCC S-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, GCWC, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
Gar-SCCC S-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* U.S. Forest Service Los Padres National Forest Land Management Plan)	CDPR, CDFG, WCB, NMFS, USFS,USFWS, MC, GCWC, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
Gar-SCCC S-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFG, WCB, NMFS, USFS, USFWS, MC, GCWC, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
Gar-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDOT, MC, CDPR, CDFG, AMBAG TWI, GCWC, TBSLT, VWA	Roads	1,4	2B	20	0	0	0	0	0	0
Gar-SCCC S-12.1	Develop and implement an estuary restoration and management plan (or periodically update; *e.g.,* Garrapata Creek Lagoon, Central Coast, California: A Preliminary Assessment, 2006)	USDOT, CDOT, MC, NMFS, CDPR, CDFG, AMBAG TWI, GCWC	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	100		0	0	0	0	0
Gar-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, NMFS, CDFG,TWI, GCWC, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
Gar-SCCC S-14.1	Review California Regional Water Quality Control Boards Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TWI, GCWC, TBSLT, VWA	Urban Effluents	1, 4, 5	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Gar-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, MC, NMFS, CDFG, GCWC, TBSLT, VWA	Wildfires	1, 4, 5	1B	100	0	0	0	0	0	0

Table 11-6. South-Central California Steelhead DPS Recovery Action Table for the Bixby Creek Watershed (Big Sur Coast BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Bixby Creek												
Bix-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON , MC, TWI, CCORP, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2A	5	96690	0	0	0	0	96690
Bix-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers within the watershed	NMFS, USF,CDFG, CCCON, MC,TWI, CCORP, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2A	5	0	0	0	0	0	0
Bix-SCCCS-4.2	Provide fish passage around dams and diversions	NMFS, USF,CDFG, CCCON, MC, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1.3. 4	1A	5	0	0	0	0	0	0
Bix-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USGS, CDFG, CCON, MC, TWI,	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
Bix-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	NMFS, USGS, CDFG, CCON CCORP, MC, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
Bix-SCCCS-9.1	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
Bix-SCCCS-9.2	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, CCORP, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
Bix-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
Bix-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* U.S. Forest Service Los Padres National Forest Land	CDPR, CDFG, WCB, NMFS, USFS, USFWS, MC, TWI, CCORP, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	Management Plan)											
Bix-SCCCS-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFG, WCB, NMFS, USFS, USFWS, MC, TWI, CCORP	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
Bix-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDOT, MC, CDPR, CDFG, AMBAG TWI, CCORP, TBSLT, VWA	Roads	1,4	2A	20	0	0	0	0	0	0
Bix-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, NMFS, CDFG CCORP,TWI	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
Bix-SCCCS-14.2	Review California Regional Water Quality Control Boards Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TWI, TBSLT, VWA	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
Bix-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, MC, NMFS, CDFG, TBSLT, VWA	Wildfires	1, 4, 5	1B	100	0	0	0	0	0	0

Table 11-7. South-Central California Steelhead DPS Recovery Action Table for the Little Sur River Watershed (Big Sur Coast BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-26	FY 1-100
Little Sur River												
LS-SCCCS-1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, CCON, MC, RCDMC, TWI, TBSLT, VWA	Agricultural Development	1, 4	2B	5	47520	0	0	0	0	47520
LS-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, MC, TWI, CCCORP , TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	1A	5	96690	0	0	0	0	96690
LS-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers within the watershed	NMFS, CDFG, CCCON, MC, TWI, CCCORP , TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	1A	5	0	0	0	0	0	0
LS-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS,CDFG, CCCON, MC, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	2A	5	91850	0	0	0	0	91850
LS-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, USFS,CDFG, CCCON, MC, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
LS-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, USFS,CDFG, CCCORP, TBSLT, VWA CCCON, MC, TWI	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
LS-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USGS, CDFG, CCCON, MC, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-26	FY 1-100
LS-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	NMFS, USGS, CDFG, CCCON, MC, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
LS-SCCCS-9.1	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
LS-SCCCS-9.2	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
LS-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
LS-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* U.S. Forest Service Los Padres National Forest Land Management Plan)	CDPR, CDFG, WCB, NMFS, USFW, MC, TW CCCORP, TWI, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
LS-SCCCS-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFG, WCB, NMFS, USFS,USFWS, USFWS, MC, TWI, CCCORP,	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-26	FY 1-100
		TBSLT, VWA										
LS-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	CDOT, MC, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1,4	3B	20	0	0	0	0	0	0
LA-SCCCS 11.2	Retrofit storm drains to filter runoff from roadways (*e.g.,* Old Coast Highway)	CDOT, MC, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1, 4	1B	20	0	00	0	0	0	0
LS-SCCCS-12.1	Develop and implement an estuary restoration and management plan (or periodically update)	USDOT, CDOT, MC, NMFS, USFS, CDFG, AMBAG TWI, CCCORP, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	0	0	0	0	0	0
LS-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, NMFS, CDFG CCCORP, TWI, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	62400	0	0	0	0	62400
LS-SCCCS-13.1	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	CCCON, MC, NMFS, CDFG, AMBAG, TWI. CCCORP	Urban Development	1, 4, 5	2B	5	398000	0	0	0	0	398000
LS-SCCCS-14.1	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TWI, TBSLT, VWA	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
LS-SCCCS-14.2	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TWI, TBSLT, VWA	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
LS-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, MC, NMFS, CDFG,	Wildfires	1, 4, 5	1B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-26	FY 1-100
		TBSLT, VWA										

Table 11-8. South-Central California Steelhead DPS Recovery Action Table for the Big Sur River Watershed (Big Sur Coast BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Big Sur River												
BS-SCCCS-1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, CCON, MC, RCDMC, TWI, TBSLT, VWA	Agricultural Development	1,3, 4	3B	5	47520	0	0	0	0	47520
BS-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	CDOT, NMFS, CDFG, CCCON, MC, TWI, CCCORP, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2A	5	96690	0	0	0	0	96690
BS-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	CDOT, NMFS, CDFG, CCCON, MC, TWI, CCCORP, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2A	5	0	0	0	0	0	0
BS-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS,CDFG, CCCON, MC, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
BS-SCCCS-4.2	Provide fish passage around dams and diversions	NMFS, USFS,CDFG, CCCON, MC, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
BS-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USGS, CDFG, CCCON, MC, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
BS-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	NMFS, USGS, CDFG, CCCON, MC, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
BS-SCCCS-9.1	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
BS-SCCCS-9.2	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
BS-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
BS-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* Pfeiffer Big Sur and Andrew Molera State Park General Plan, U.S. Forest Service Los Padres National Forest Land Management Plan)	CDPR, CDFG, CCCON, WCB, NMFS, USFS, USFWS, MC, TWI, CCCORP, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
BS-SCCCS-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFG, CCCON, WCB, NMFS, USFS, USFWS, MC, TWI, CCCORP	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
BS-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	CDOT, MC, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1,4	2B	20	0	0	0	0	0	0
BS-SCCCS-11.2	Develop and implement plan to remove or reduce approach-fill road and roads	CDOT, MC, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1,4	3B	20	0	0	0	0	0	0
BS-SCCCS-12.1	Develop and implement an estuary restoration and management plan	CDOT, MC, NMFS, USFS, CDFG, AMBAG TWI, CCCORP, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1340000	0	0	0	0	1340000
BS-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, NMFS, USFS, CDFG, CCCORP, TWI, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
BS-SCCCS-14.1	Review, assess and modify residential and commercial wastewater septic treatment facilities	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TW, TBSLT, VWA I	Urban Effluents	1, 4, 5	2B	100	0	0	0	0	0	0
BS-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TWI, TBSLT, VWA	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
BS-SCCCS-14.3	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TWI, TBSLT, VWA	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
BS-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, MC, NMFS, CDFG, TBSLT, VWA	Wildfires	1, 4, 5	1B	100	0	0	0	0	0	0

Table 11-9. South-Central California Steelhead DPS Recovery Action Table for the Willow Creek Watershed (Big Sur Coast BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Willow Creek												
WC-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	CDOT, NMFS, CDFG, CCCON, MC, TWI, CCCORP, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2A	5	96690	0	0	0	0	96690
WC-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	CDOT, NMFS, CDFG, CCCON, MC, TWI, CCCORP, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2A	5	0	0	0	0	0	0
WC-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS,CDFG, CCCON, MC, TWI, TBSLT, VWA	Dams and Surface Water Diversions			5	91850	0	0	0	0	91850
WC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USGS, CDFG, CCCON, MC, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
WC-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	NMFS, USGS, CDFG, CCCON, MC, TWI, TBSLT, VWA	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
WC-SCCCS-9.1	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, M, TBSLT, VWA C, TWI, CCCORP	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
WC-SCCCS-9.2	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
WC-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CNPS, CDPR, MC, TWI,	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		CCCORP, TBSLT, VWA										
WC-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* U.S. Forest Service Los Padres National Forest Land Management Plan)	CDPR, CDFG, CCCON, WCB, NMFS, USFS, USFWS, MC, TWI, CCCORP, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
WC-SCCCS-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFG, CCCON, WCB, NMFS, USFW, MC, TWI, CCCORP, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
WC-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	CDOT, MC, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1,4	2B	20	0	0	0	0	0	0
WC-SCCCS-11.2	Develop and implement a plan to remove or reduce approach-fill for railroad lines and roads	CDOT, MC, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1,4	3B	20	0	0	0	0	0	0
WC-SCCCS-12.1	Develop and implement an estuary restoration and management plan	CDOT, MC, CDPR, CDFG, AMBAG TWI	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	335000	0	0	0	0	335000
WC-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, NMFS, USFS, CDFG, CCCORP, TWI, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
WC-SCCCS-14.2	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TWI	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
WC-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, MC, NMFS, CDFG, TBSLT, VWA	Wildfires	1, 4, 5	1B	100	0	0	0	0	0	0

Table 11-10. South-Central California Steelhead DPS Recovery Action Table for the Salmon Creek Watershed (Big Sur Coast BPG).

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Salmon Creek												
SC-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	CDOT, NMFS, CDFG, CCCON, MC, TWI, CCCORP, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	1A	5	96690	0	0	0	0	96690
SC-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	CDOT, NMFS, CDFG, CCCON, MC, TWI, CCCORP, TBSLT, VWA	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	1A	5	0	0	0	0	0	0
SC-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* U.S. Forest Service Los Padres National Forest Land Management Plan)	CDPR, CDFG, CCCON, WCB, NMFS, USFS,USFWS, MC, TWI, CCCORP, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
SC-SCCCS-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFG, CCCON, WCB, NMFS, UFS, USFWS, MC, TWI, CCCORP, TBSLT, VWA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
SC-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	CDOT, MC, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1,4	2B	20	0	0	0	0	0	0
SC-SCCCS-11.2	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	CDOT, MC, CDPR, CDFG, AMBAG TWI, TBSLT, VWA	Roads	1, 4	2B	20	0	0	0	0	0	0
SC-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, NMFS, USFS, CDFG, CCCORP, TWI, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
SC-SCCCS-14.2	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFG, AMBAG, TWI, TBSLT, VWA	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Potential Collaborators	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SC-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP, USFS, USFWS, MC, NMFS, CDFG, TBSLT, VWA	Wildfires	1, 4, 5	1B	100	0	0	0	0	0	0

12. San Luis Obispo Terrace Biogeographic Population Group

"Assessment at the group level indicates a priority for securing inland populations in southern Coast Ranges and Transverse Ranges, and a need to maintain not just the fluvial-anadromous life-history form, but also lagoon-anadromous and freshwater-resident forms in each population."

NOAA Fisheries Technical Recovery Team
Viability Criteria for South-Central and Southern California Steelhead, 2007

12.1 LOCATION AND PHYSICAL CHARACTERISTICS

The San Luis Obispo Terrace BPG region extends north-to-south about 75 miles to include the extreme southwest corner of Monterey County and almost the entire length of coastal San Luis Obispo County. It consists of eleven small to moderate-sized watersheds that drain the steep coastal slopes of the southern Santa Lucia Range. This BPG region is similar to the Big Sur Coast BPG region in terms of its upper watersheds, but because the spine of the Santa Lucia Range veers inland to the south, the lower portions of the watersheds in the San Luis Obispo Terrace BPG region are relatively flat and cut across coastal terraces before entering the Pacific Ocean.

From north to south, 12 watersheds are included in this BPG: San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Big Pico Creek, San Simeon Creek, Santa Rosa Creek, Morro Creek, Chorro Creek (Morro Bay), Los Osos Creek (Morro Bay), San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek. (Figure 12-1). The Morro Bay region includes the separate watersheds of Morro Creek, which empties into the Pacific Ocean north of Morro Bay, and Chorro and Los Osos creeks, which (along with several smaller drainages) flow into Morro Bay forming an extensive estuarine wetland. Separate CAP Workbooks were prepared for Morro, Chorro, and Los Osos creeks (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

San Carpoforo Creek Estuary

Watersheds in the San Luis Obispo BPG vary in size by over an order of magnitude, from less than 5,300 acres in the Little Pico Creek watershed to almost 100,000 acres in the Arroyo Grande Creek watershed. Average annual precipitation shows some spatial variation across the component watersheds and total seasonal rainfall in this region is highly variable from year to year, depending on the intensity and duration of Pacific storms.

In general, the higher elevations receive greater amounts of precipitation, and persistent spring and summer coastal fog is characteristic of this region. All of the watercourses in this BPG are perennial (though some reaches may be seasonally reduced to isolated pools, particularly during low rainfall years).

Arroyo Grande Creek

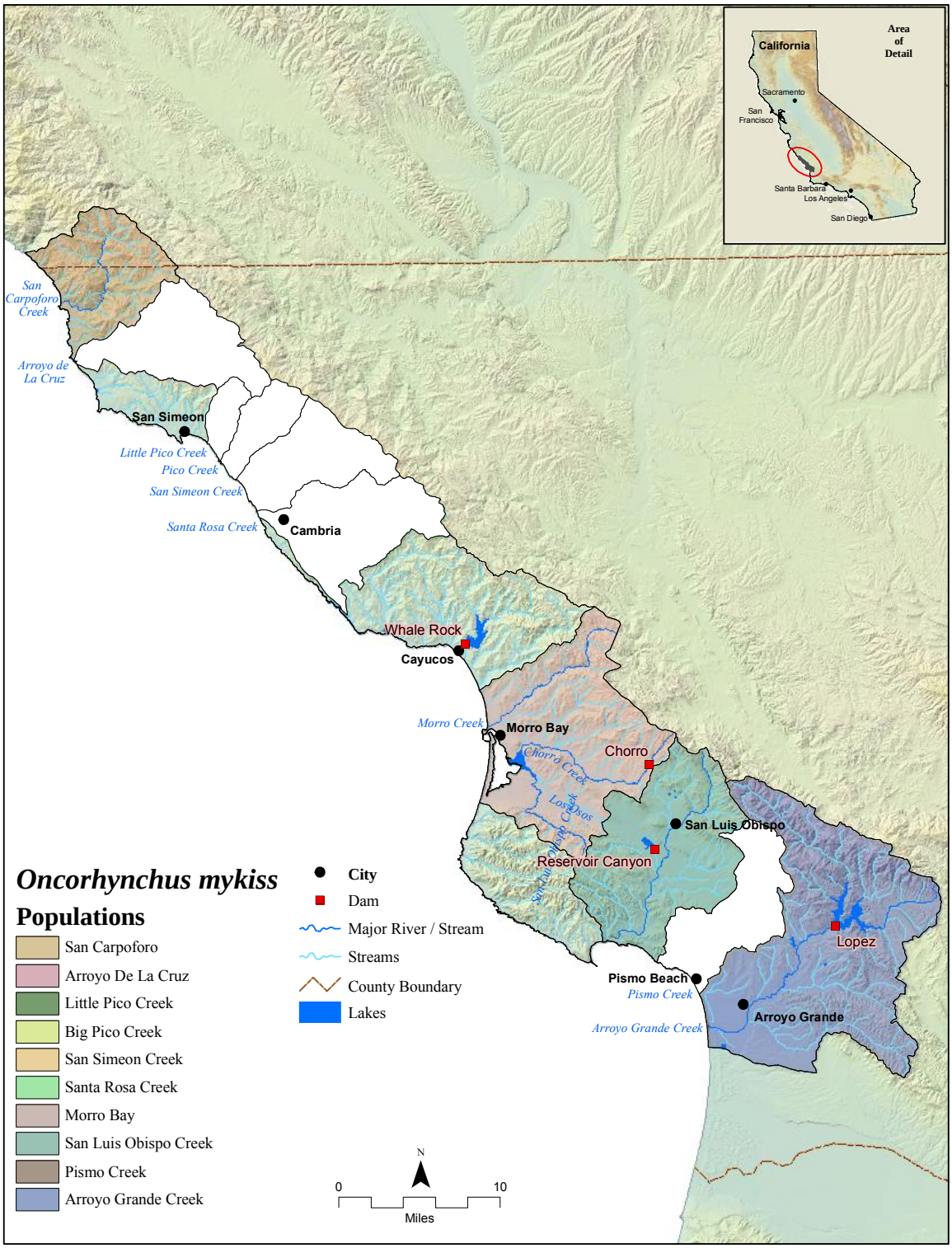
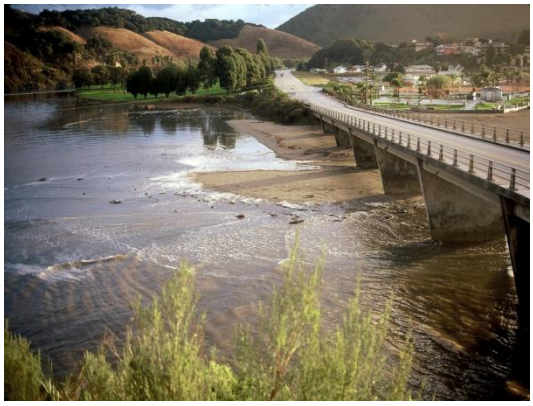


Figure 12-1. The San Luis Obispo Terrace BPG region. Twelve steelhead populations/watersheds were analyzed in this region, including three in the Morro Bay region.

12.2 LAND USE

Table 12-1 summarizes land use and population density in this BPG region. Despite a relatively low total human population density, the San Luis Obispo Terrace BPG region has over 2.5 times the population density of any BPG region in the SCCCS Recovery Planning Area, averaging about 248 persons per square mile.



San Luis Obispo Creek Estuary

Population density increases dramatically south of the San Simeon Creek watershed such that over 99 percent of the total population in the San Luis Obispo Terrace BPG is concentrated in the seven southern watersheds: Santa Rosa Creek, Morro Creek, Chorro Creek (Morro Bay), Los Osos Creek (Morro Bay), San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek. The San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Big Pico Creek, and San Simeon Creek watersheds are largely undeveloped (although there are ranching and agricultural activities in several of these watersheds), or have very low population densities. The Los Padres National Forest encompasses a federally designated wilderness area: the Santa Lucia Wilderness Area within the San Luis Obispo Creek and Arroyo Grande Creek watersheds (Hunt & Associates 2008b, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Stephenson and Calcarone 1999, California Department of Water Resources 1978).

The strong increasing gradient in population density towards the southern portions of this BPG region is reflected in land-use changes, such as increasing agricultural conversion of watershed lands, increasing urbanization (including small cities, such as Morro Bay, San Luis Obispo, Grover Beach, Pismo Beach, Shell Beach, and Arroyo Grande), increasing private ownership of land, and correspondingly lower amounts of open space (Table 12-1). The coastal terraces of the southern watersheds receive high recreational and urban use. There are a number of dams in this region: Whale Rock Dam on Old Creek, Chorro Dam on Chorro Creek a privately-owned dam on West Corral de Piedra, tributary of Pismo Creek, Lopez Dam on Arroyo Creek, and Terminal Dam on a tributary of Arroyo Grande Creek. The reservoirs created by these dams are used for municipal water supply, agricultural irrigation, and recreation (California Department of Fish and Game 2011b, California Department of Water Resources 1988).

Lopez Dam – Arroyo Grande Creek

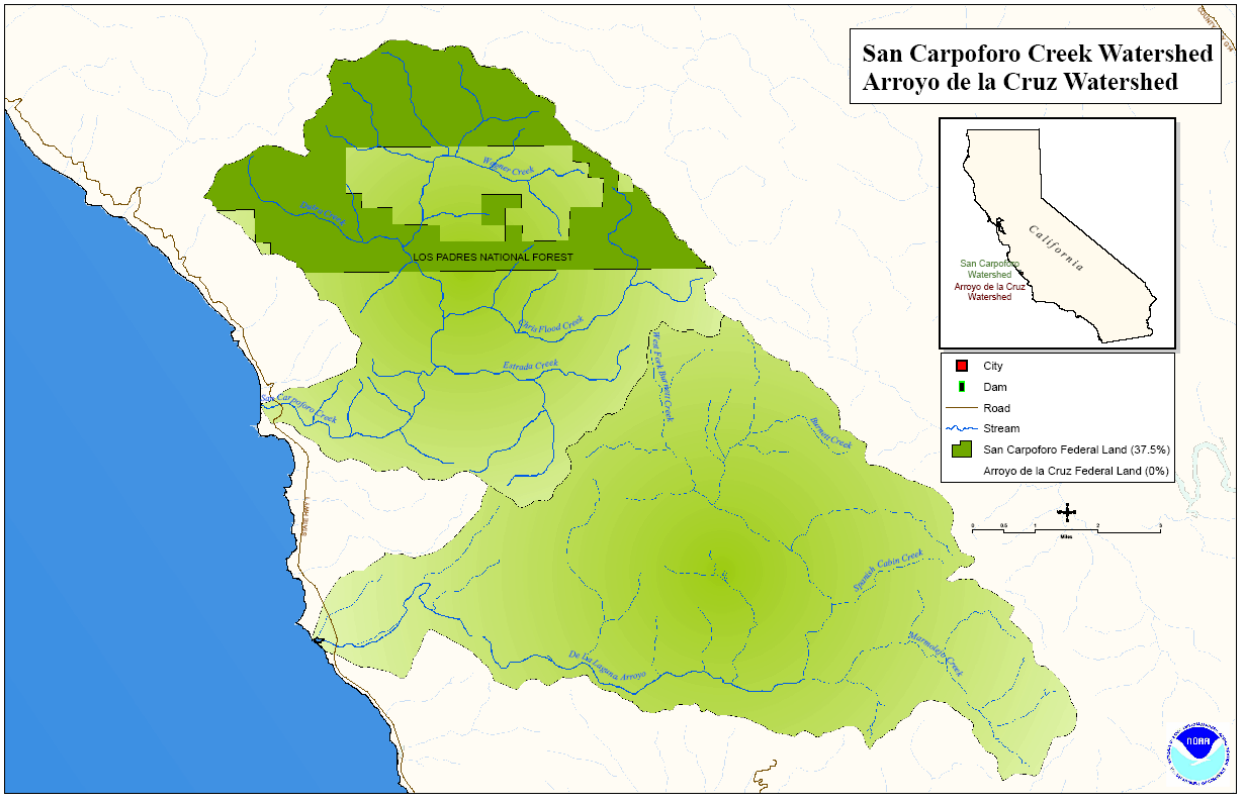


Figure 12-2. Federal and Non-Federal Land Ownership within the San Carpoforo Creek and Arroyo de la Cruz Watersheds.

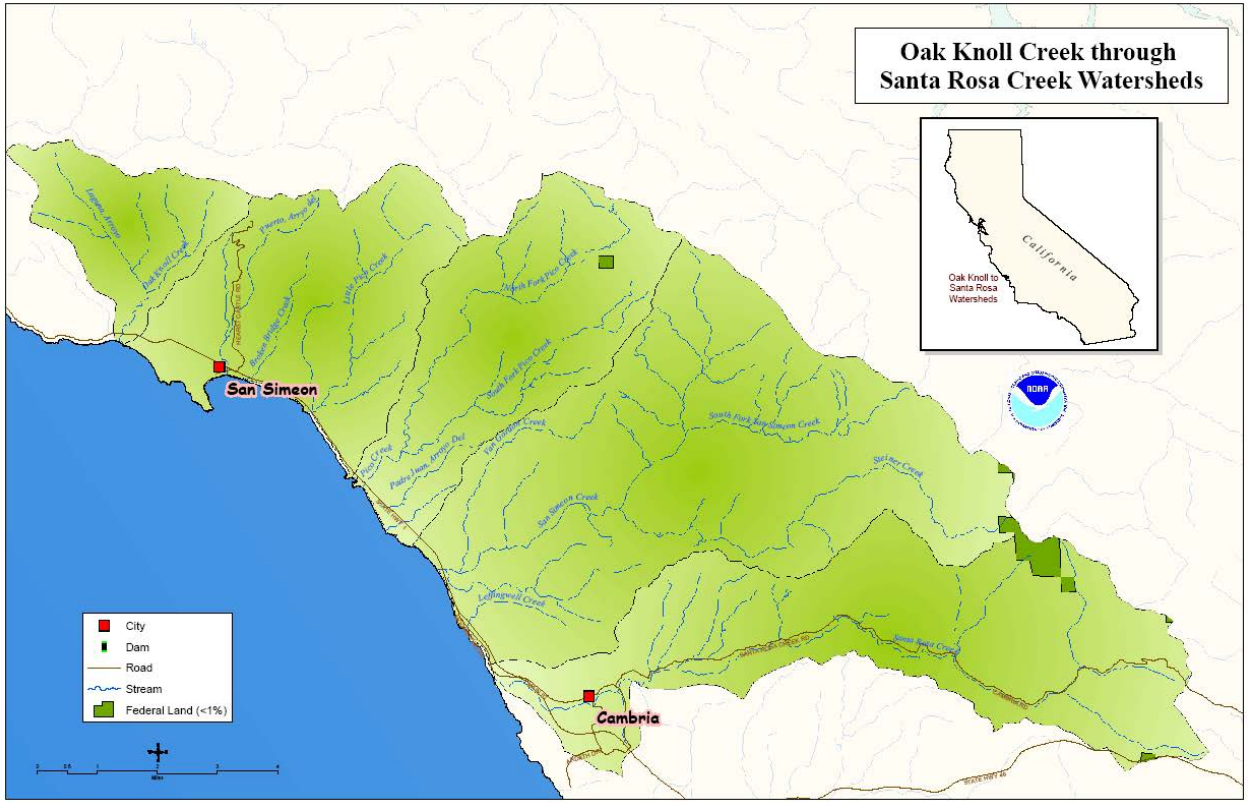


Figure 12-3. Federal and Non-Federal Land Ownership within the Oak Knoll Creek through the Santa Rosa Creek Watersheds.

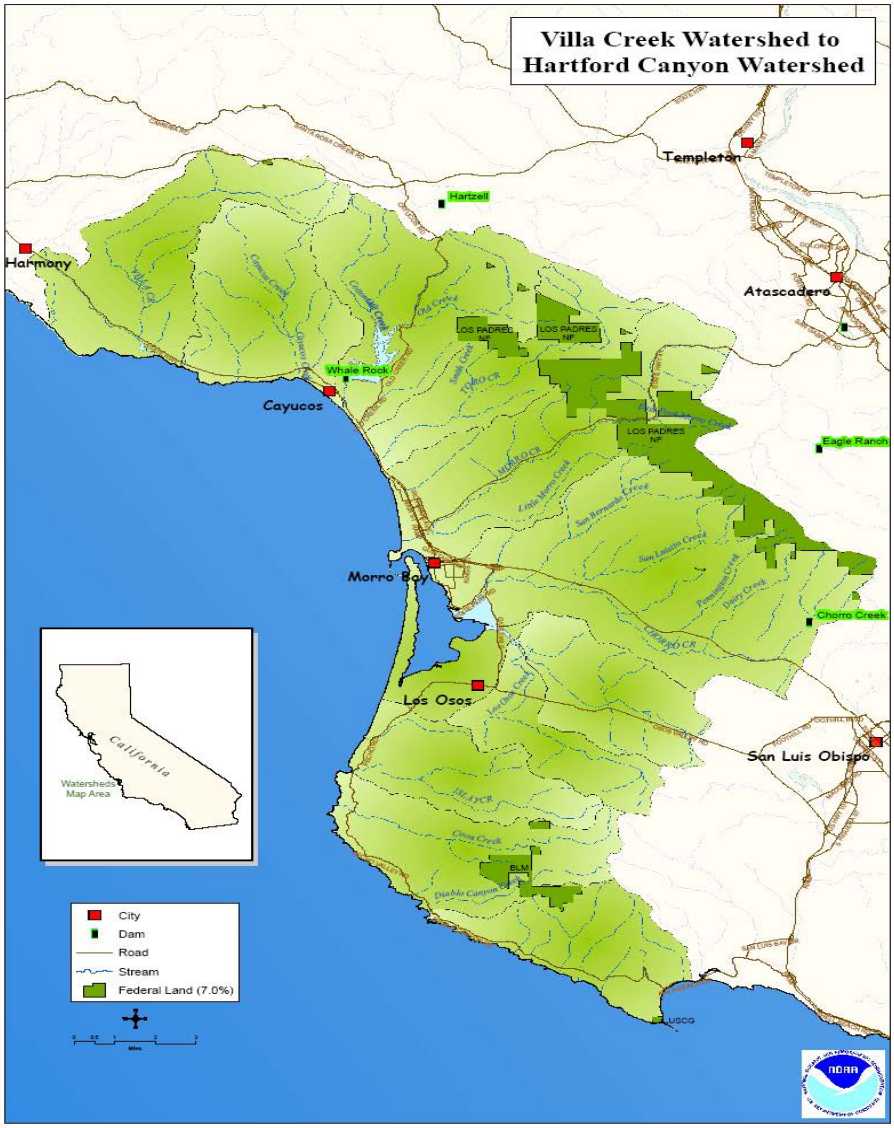


Figure 12-4. Federal and Non-Federal Land Ownership within the Villa Creek through the Hartford Canyon Watersheds.

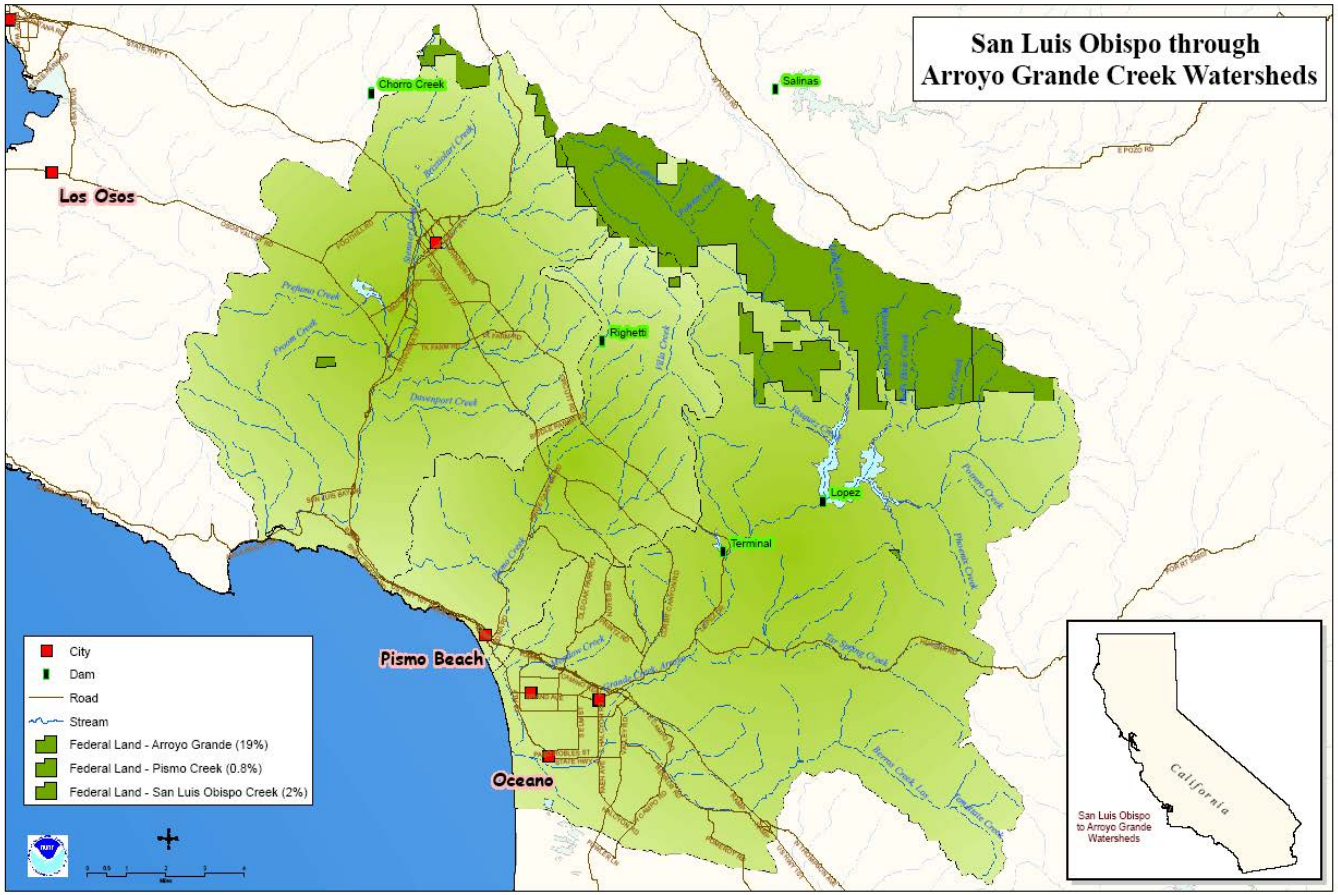


Figure 12-5. Federal and Non-Federal Land Ownership within the San Luis Obispo through the Arroyo Grande Creek Watersheds

12.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for 12 watersheds and sub-watersheds in the San Luis Obispo Terrace BPG region. The CAP Workbook analyses rated overall habitat conditions for steelhead as "Very Good" or "Good" in the northernmost watersheds, and "Fair" in the watersheds in the central and southern portions of this BPG region.

Arroyo de la Cruz Creek

There is a dramatic shift in the habitat quality in watersheds south of Pico Creek, reflecting increasing land-use changes associated with higher human population densities.

Arroyo de la Cruz Estuary

Although mostly or entirely privately owned, the northernmost watersheds in this BPG: San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, and Pico Creek are relatively unaltered (Watson *et al.* 2008, California Conservation Corps 2005, Wurster *et al.* 2002, Stephenson and Calcarone 1999, Nelson 1994, California Department of Water Resources 1978, Knable 1978).

Table 12-1. Physical and Land Use Characteristics of Watersheds in the San Luis Obispo Terrace BPG region.

PHYSICAL CHARACTERISTICS						LAND USE			
WATERSHEDS (north to south)	**Area** (acres)[1]	**Area** (sq.miles)[1]	**Stream Length**[2] (miles)	**Ave. Ann. Rainfall**[3] (inches)	**Total Human Population**	**Public Ownership***	**Urban Area**[5]	**Agriculture/ Barren**[5]	**Open Space**[5]
San Carpoforo Creek	29,316	46	64	19.7	74	30%	0.1%	0.1%	> 99%
Arroyo de la Cruz	27,774	43	65	19.4	3	0.1%	0.2%	0.2%	> 99%
Little Pico Creek	5,229	8	13	18.1	1	0%	0%	0.2%	> 99%
Big Pico Creek	9,687	15	29	18.1	477	0.3%	1%	< 0.1%	99%
San Simeon Creek	22,247	35	57	17.8	450	0.1%	1%	1%	98%
Santa Rosa Creek	31,484	49	81	17.2	4,459	1%	5%	3%	92%
Morro Bay (*)	65,993	103	127	18.8	32,843	17%	10%	6%	84%
San Luis Obispo Creek	55,554	87	98	18.9	57,762	2%	16%	6%	78%
Pismo Creek	25,355	40	49	18.4	5,408	0.1%	6%	9%	85%
Arroyo Grande Creek	97,873	153	175	18.0	48,421	20%	7%	9%	84%
TOTAL or AVERAGE	**370,512**	**579**	**758**	**18.4**	**149,906**	**7%**	**5%**	**3%**	**92%**

[1] From: CDFFP CalWater 2.2 Watershed delineation, 1999 (www.ca.nrcs.usda.gov/features/calwater/)
[2] From: CDFG 1:1,000,000 Routed stream network, 2003 (www.calfish.org/)
[3] From: USGS Hydrologic landscape regions of the U.S., 2003 (1 km grid cells)
[4] From: CDFFP Census 2010 block data (migrated), CalFire FRAP (http://frap.cdf.ca.gov/data/frapgisdata/select.asp)
[5] From: CDFFP Multi-source land cover data (v02_2), 2002 (100 m grid cells) (http://frap.cdf.ca.gov/data/frapgisdata/select.asp)
** National Forest Lands only; Military Reservations or State and County Parks not included.*

12.4 THREATS AND THREAT SOURCES

Information identified in the CAP Workbooks on 30 habitat and land-use indicators for the San Luis Obispo Terrace BPG was supplemented by additional information developed since the preparation of the CAP Workbooks and incorporated into the threat assessment. All or most of the "threats" identified in the four northern watersheds (San Carpoforo, Arroyo de la Cruz, Little Pico, and Pico creeks) are rated as low severity. In fact, near-natural conditions identified in these northern watersheds reflect prevailing low-intensity land use. Pico Creek has a single threat rated as "high" – extensive reaches of the mainstem and North Fork frequently go dry in summer posing fish-passage impediments to juveniles and smolts. This condition is natural, but can be exacerbated by groundwater extraction and surface water diversions (Hunt & Associates 2008b, Kier Associates and National Marine Fisheries Service 2008a, 2008b; see also, Nelson 1994).

Pico Creek Estuary

Although the San Simeon Creek watershed has a relatively low human population density (about 19 persons/square mile) and less than two percent of the watershed has been converted to row crop agriculture, most of this agricultural conversion has occurred within the narrow floodplain of San Simeon Creek, thereby concentrating land-use impacts in this area. The stream and riparian corridor are subject to a number of severe to very severe threats related to land use: groundwater extraction, severe stream incision (caused by confinement of the active channel due to encroachment of agriculture on the floodplain), cattle grazing within the active channel, and the presence of ranch houses and the main road through the watershed. Wastewater treatment facilities near the San Simeon Creek estuary and a proposed desalination plant have the potential to adversely affect the lower stream reaches and estuary through direct or indirect discharges of effluents. Development of recreational facilities (San Simeon State Park) at the mouth of the creek and the placement of the Highway 1 bridge abutments has eliminated 50 percent of the estuary. A recent potential threat to estuarine habitat is the development of desalinization facilities that withdraw water from groundwater sources that contribute to and maintain estuarine water levels, particularly during the summer when the sandbar closes the estuary off to the ocean D.W. Alley & Associates 2008, 2007, 2006a, 2006b, 2001, Nelson *et al*. 2005b).

San Simeon Creek

Fourteen anthropogenic activities ranked as the top five sources of threats to anadromous *O. mykiss* viability in this BPG region (Table 12-2). These sources are not mutually exclusive and can be grouped into a few general threat categories related to the land use. Although open space is by far the dominant land use within all of the watersheds in this BPG region, with less than 10 percent of any watershed converted to agricultural production, watersheds south of San Simeon Creek share a common pattern of urban and agricultural development that largely determines the degree habitat degradation in these drainages. These watersheds are primarily under private ownership, with land-use activities concentrated along the narrow, coastal terrace floodplains, which magnifies impacts to instream and riparian habitats in these locations. Recurring sources of threats to instream and riparian habitats here include: agricultural conversion of the floodplain, increased road density and placement of roads in or near the riparian corridor, and the development of towns and cities on the floodplains, frequently at or near the estuary. Other important sources of threats to anadromous *O. mykiss* in this BPG region include: sedimentation, substrate embeddedness, excessive groundwater extraction, numerous culverts and road crossings that serve as passage barriers, recreational facilities, non-point pollution as well as nutrient and coliform bacteria loading from agricultural and wastewater treatment effluents, and channelization).

Santa Rosa Creek

Dams and surface water diversions on Morro Creek, Chorro Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek that serve agricultural, urban, and recreational purposes have significantly altered natural sediment and hydrological processes in these watersheds. Dams have also isolated native non-anadromous *O. mykiss* in the upper watersheds of these drainages; some of which may have the potential to exhibit an anadromous life-history (Boughton 2006). The reservoirs behind these dams create favorable habitat conditions for several species of non-native fishes and bullfrogs that may affect one or more life-history stages of *O. mykiss* either directly (*e.g.*, predation) or indirectly (*e.g.*, competition for food). Non-native fishes, crayfish, and/or amphibians also occur in the mainstems of the many watersheds in this BPG region (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b; see also, Stillwater Sciences 2012, Central Coast Salmon Enhancement 2009, 2005, D. W. Alley & Associates 2008, 2007, 2006b, 2006a, 2001, 1996, 1997, Rischbieter 2008, 2007, 2006, 2004, The Land Conservancy of San Luis Obispo County 2008, Swanson Hydrology & Geomorphology 2006a, 2006b, 2004, Tri-County Fish Team 2006, California Conservation Corps 2005, Nelson *et al*. 2005a, 2005b, Close and Smith 2004, Thomas

R. Payne and Associates 2004, 2001, 2000, Dvorsky 2003, Ross Taylor and Associates 2003, Spina 2003, Stark and Wilkison 2002, Otte and McEwan 2001, Cleveland 1995).

Little Pico Creek

The Pico Creek, San Simeon Creek, Santa Rosa Creek, Morro Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek estuaries have lost between 50 percent and 80 percent of their former size as a result of development of recreational facilities (*e.g.*, State and County parks), Highway 1 bridge construction, and/or agricultural or urban development.

Pismo Creek Estuary

Fires have been relatively minor source of disturbance in the northern watersheds of this BPG region where less than 4 percent of watershed lands have burned in the past 25 years; however, between 18 percent and 44 percent of the Morro Creek, Chorro Creek, Los Osos Creek, San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek watersheds to the south have burned over this period. Sedimentation and increased substrate embeddedness resulting from overgrazing and agricultural developments are significant habitat stressors in these watersheds. Increased road density and human population density in these fire-prone watersheds has served to increase fire frequency.

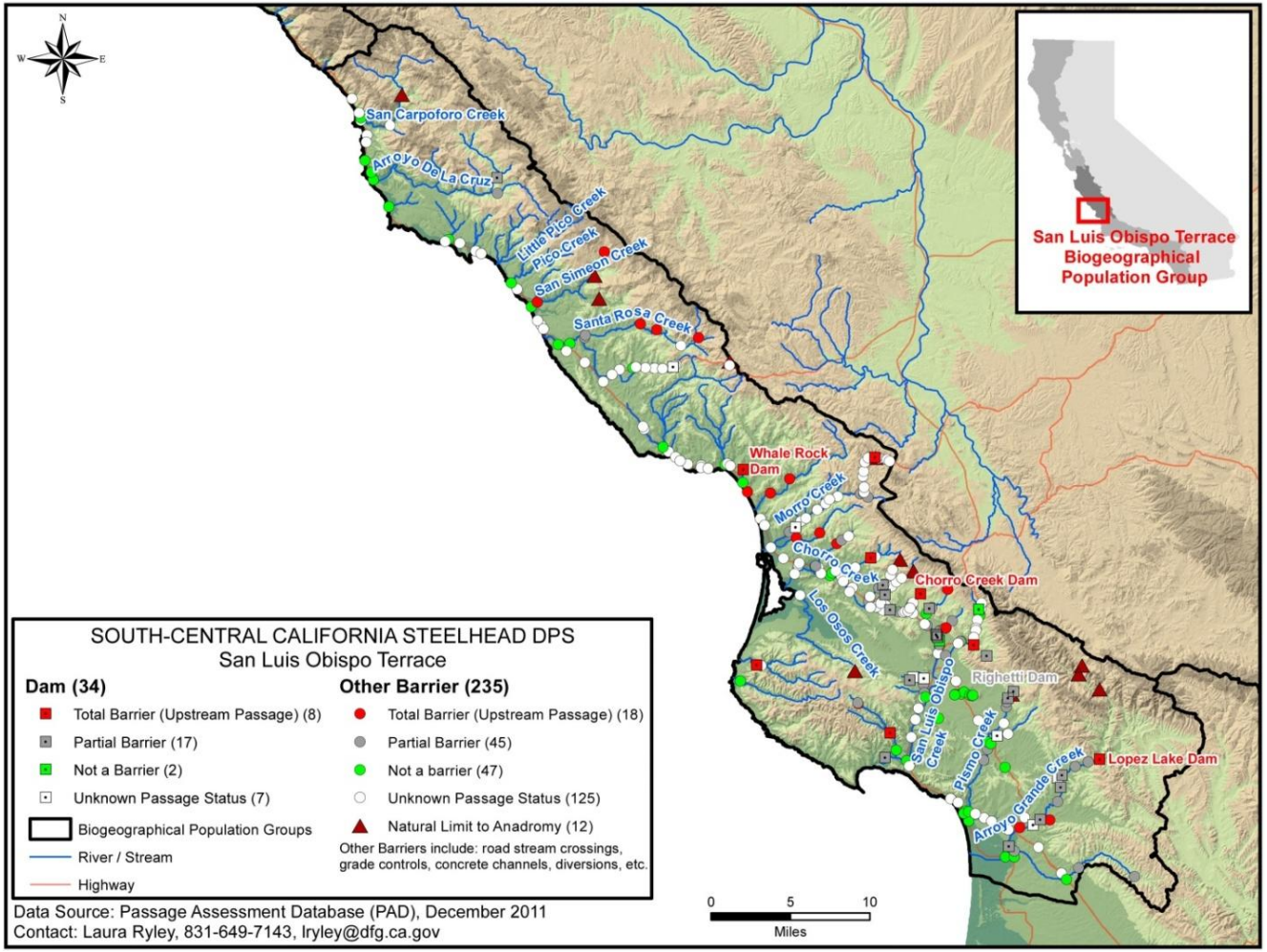


Figure 12-7. Major Fish Passage Barriers, San Luis Obispo Terrace BPG.

Table 12-2. Threat source rankings in the San Luis Obispo Terrace BPG (see CAP Workbooks for individual watersheds for details).

THREAT SOURCES	**San Luis Obispo BPG Component Watersheds** (north to south)											
	San Carpoforo Creek*	Arroyo de la Cruz*	Little Pico Creek*	Pico Creek	San Simeon Creek	Santa Rosa Creek	Morro Creek	Chorro Creek	Los Osos Creek	San Luis Obispo Creek	Pismo Creek	Arroyo Grande Creek
Agricultural Development	Dark green	Light green	Dark green	Dark green	Red	Red	Red	Red	Red	Red	Red	Red
Groundwater Extraction	Dark green	Light green	Dark green	Dark green	Red	Red	Red	Red	Red	Light green	Red	Red
Dams and Surface Water Diversions	Dark green	Dark green	Dark green	Dark green	Light green	Red	Red	Red	Light green	Red	Red	Red
Levees and Channelization	Dark green	Dark green	Dark green	Dark green	Red	Red	Yellow	Light green	Light green	Red	Yellow	Red
Culverts and Road Crossings (Other Passage Barriers)	Dark green	Dark green	Dark green	Dark green	Light green	Light green	Yellow	Light green	Light green	Yellow	Light green	Light green
Urban Development	Dark green	Dark green	Dark green	Dark green	Light green	Red	Dark green	Light green	Light green	Yellow	Red	Yellow
Roads	Dark green	Dark green	Light green	Light green	Red	Light green	Light green	Light green	Light green	Yellow	Yellow	Red
Recreational Facilities	Dark green	Dark green	Dark green	Dark green	Red	Light green	Dark green	Light green	Light green	Yellow	Red	Light green
Urban Effluents	Dark green	Dark green	Dark green	Dark green	Dark green	Yellow	Dark green	Red	Light green	Yellow	Yellow	Light green
Agricultural Effluents	Dark green	Dark green	Light green	Light green	Dark green	Light green	Light green	Red	Light green	Light green	Light green	Yellow

Key: Threat cell colors represent threat rating from CAP Workbook: Red = Very High threat; Light green = Medium threat; Yellow = High threat; Dark green = Low threat.

12.5 SUMMARY

The watersheds in the San Luis Obispo Terrace BPG exhibit the widest range of habitats conditions for steelhead in the SCCCS Recovery Planning Area. The San Carpoforo Creek, Arroyo de la Cruz Creek, Little Pico Creek, and Pico Creek watersheds contain the best preserved and protected streams in the region. Although threats to these streams are currently low relative to other watersheds within the SCCCS Recovery Planning Area, though there are significant issues regarding water extractions from these watersheds to support existing recreational development and agricultural operations. Additionally, conditions could change in the future because much land in this BPG region is under private ownership and subject to additional development that could further increase water extraction from these watersheds; all watersheds are traversed by Highway 1, and all support low to moderately intense livestock ranching operations. San Luis Obispo Creek, Pismo Creek, and Arroyo Grande Creek exhibit the highest number and severity of threat sources within this BPG region.

As a result of the substantial increase in human population density and related development pressures in the southern portion of this BPG region, recovery actions should be focused on the watersheds south of the community of San Simeon (although efforts to ensure continued protection of the more northern watersheds are also important). Recovery actions in these watersheds should concentrate on: reducing the severity of anthropogenic impacts from water diversions, groundwater extractions, and related agricultural and urban development that adversely impact rearing habitat; minimizing erosion and sedimentation caused by upslope development and land uses (including roads, overgrazing, and agricultural and urban development); removing impediments to fish passage along the mainstems and tributaries of affected drainages to facilitate connectivity between the ocean, estuaries and the upstream spawning and rearing habitats; and restoring channel morphology and riparian habitats affected by urban and agricultural floodplain encroachment and related flood control activities. Additionally, degraded estuarine conditions stemming from filling, artificial sandbar manipulation, and both point and non-point waste discharges should be further evaluated and addressed for the San Luis Obispo Terrace BPG. Table 12-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG. The threat sources discussed in this chapter should be the focus of a variety of recovery actions to address specific stresses associated with these threats. Spatial and temporal data acquired on specific indicators associated with sources of threats or stresses, such as water temperature, pH, nutrients, *etc*., are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the San Luis Obispo Terrace BPG. Tables 12-4 through 12-10 below rank and describe proposed recovery actions for each sub-watershed in the San Luis Obispo Terrace BPG including the estimated cost for implementing such actions in five year increments, and where applicable extended out to 100 years, though many of the recovery actions can and should be achieved within a shorter period (Hunt & Associates 2008a 2008b, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

Table 12-3. Critical recovery actions for Core 1 populations within the Big Sur Coast BPG.

POPULATION	CRITICAL RECOVERY ACTIONS
San Simeon Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage barriers 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. Manage instream mining to minimize impacts to migration, spawning and rearing habitat. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
Santa Rosa Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage barriers 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
San Luis Obispo Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage barriers 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
Pismo Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage barriers 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
Arroyo Grande Creek	Implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including bypass flows around diversions, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or modify instream fish passage barriers 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. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.

South Central California Steelhead DPS Recovery Action Tables Identification Key, San Luis Obispo Terrace BPG (Tables 12-4 to 12-14).

Recovery Action Number Key: XXXX – SCCCS – 1.2	
XXXX	Watershed
SCCCS	Species Identifier – South Central California Steelhead
1	Threat Source
2	Action Identity Number

Action Rank	
A	Action addresses the first listing factor regarding the destruction or curtailment of the species' habitat
B	Action addresses one of the other four listing factors

XXXX ID Table	
SCp	San Carpoforo
AC	Arroyo de la Cruz
LP	Little Pico Creek
PC	Pico Creek
SS	San Simeon Creek
SR	Santa Rosa Creek
MC	Morro Creek
CC	Chorro Creek
LO	Los Osos Creek
SLO	San Luis Obispo Creek
Pis	Pismo Creek
AG	Arroyo Grande Creek

Threat Source Legend	
1	Agricultural Development
2	Agricultural Effluents
3	Culverts and Road Crossings (Passage Barriers)
4	Dams and Surface Water Diversions
5	Flood Control Maintenance
6	Groundwater Extraction
7	Levees and Channelization
8	Mining and Quarrying
9	Non-Native Species
10	Recreational Facilities
11	Roads
12	Upslope/Upstream Activities
13	Urban Development
14	Urban Effluents
15	Wildfires

See Chapter 8, Table 8-1 for Detailed Description of Recovery Actions. See Appendix E for discussion of recovery action cost estimates.

Table 12-4. South-Central California Steelhead DPS Recovery Action Table for the San Carpoforo Creek Watershed (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
San Carpoforo Creek												
ScP-SCCCS-1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	2B	5	47520	0	0	0	0	47520
ScP-SCCCS-1.2	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	2B	5	0	0	0	0	0	0
ScP-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Effluents	1, 4	3B	100	0	0	0	0	0	0
ScP-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Dams and Surface Water Diversions	1, 3, 4	3A	5	91850	0	0	0	0	91850
ScP-SCCCS-4.2	Provide fish passage around dams and diversions	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Dams and Surface Water Diversions	1,3, 4	3A	5	0	0	0	0	0	0
ScP-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TCFT TBSLT, VWA, TCFT	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
ScP-SCCCS-6.2	Develop and implement groundwater monitoring and management program	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
ScP-SCCCS-9.2	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
ScP-SCCCS-9.3	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
ScP-SCCCS-9.1	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
ScP-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* U.S. Forest Service Los Padres National Forest Land Management Plan U.S. Forest Service Plan for the Silver Peak Wilderness Area)	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
ScP-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
ScP-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT,	Roads	1, 4	3B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		VWA, TCFT										
ScP-SCCCS-11.2	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, TCFT	Roads	1, 4	3B	20	0	0	0	0	0	0
ScP-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	4154000	0	0	0	0	4154000
ScP-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, SLOC, NMFS, CDFG, LPFW, TCLT, TBSLT, VWA, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
ScP-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
ScP-SCCCS-14.1	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
ScP-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Wildfires	1, 4, 5	2B	100	0	0	0	0	0	0

Table 12-5. South-Central California Steelhead DPS Recovery Action Table for the Arroyo de la Cruz Watershed (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Arroyo de la Cruz												
AC-SCCCS-1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	2B	5	47520	0	0	0	0	47520
AC-SCCCS-1.2	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	2B	5	0	0	0	0	0	0
AC-SCCCS-1.3	Develop, adopt and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	2B	20	0	0	0	0	0	0
AC-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT	Agricultural Effluents	1, 4	3B	100	0	0	0	0	0	0
AC-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	3A	5	91850	0	0	0	0	91850
AC-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA,	Dams and Surface Water Diversions	1,3, 4	3A	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		CCSE, TCFT										
AC-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Dams and Surface Water Diversions	1,3, 4	3A	5	0	0	0	0	0	0
AC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
AC-SCCCS-6.2	Develop and implement groundwater monitoring and management program	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
AC-SCCCS-9.1	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
AC-SCCCS-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
AC-SCCCS-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
AC-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* U.S. Forest Service Los Padres National Forest Land Management Plan)	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
AC-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
AC-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, TCFT	Roads	1, 4	3B	20	0	0	0	0	0	0
AC-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1742000	0	0	0	0	174200
AC-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, SLOC, NMFS, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
AC-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
AC-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
AC-SCCCS-15.1	Develop and implement an integrated wildlands fire and hazardous fuels plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Wildfires	1, 4, 5	2B	100	0	0	0	0	0	0

Table 12-6. South-Central California Steelhead DPS Recovery Action Table for the Little Pico Creek Watershed (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Little Pico Creek												
LP-SCCCS-1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	3B	5	47520	0	0	0	0	47520
LP-SCCCS-1.2	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	3B	5	0	0	0	0	0	0
LP-SCCCS-1.3	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	3B	20	0	0	0	0	0	0
LP-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT	Agricultural Effluents	1, 4	3B	100	0	0	0	0	0	0
LP-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	3A	5	91850	0	0	0	0	91850
LP-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA,	Dams and Surface Water Diversions	1, 3, 4	2B	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		CCSE, TCFT										
LP-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, TBSLT, VWA, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 3, 5	2A	5	96690	0	0	0	0	96690
LP-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, CDFG, CCCON, SLOC, TBSLT, VWA, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 3, 5	2A	5	0	0	0	0	0	0
LP-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
LP-SCCCS-6.2	Develop and implement groundwater monitoring and management program	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
LP-SCCCS-9.1	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
LP-SCCCS-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
LP-SCCCS-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
LP-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* U.S. Forest Service Los Padres National Forest Land Management Plan)	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
LP-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
LP-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, TCFT	Roads	1, 4	3B	20	0	0	0	0	0	0
LP-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1474000	0	0	0	0	1474000
LP-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
LP-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
LP-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* San Simeon Community Service District Wastewater Treatment Facilities)	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
LP-SCCCS-15.1	Develop and implement an integrated wildlands fire and hazardous fuels plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Wildfires	1, 4, 5	2B	100	0	0	0	0	0	0

Table 12-7. South-Central California Steelhead DPS Recovery Action Table for the Pico Creek Watershed (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Pico Creek												
PC-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	3B	20	0	0	0	0	0	0
PC-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	3B	5	47520	0	0	0	0	47520
PC-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	3B	5	0	0	0	0	0	0
PC-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT	Agricultural Effluents	1, 4	3B	100	0	0	0	0	0	0
PC-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, TBSLT, VWA, CCSE,TCFT	Culverts and Road Crossings (Passage Barriers)	1, 3, 5	2A	5	96690	0	0	0	0	96690
PC-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, CDFG, CCCON, SLOC, TBSLT, VWA, CCSE,TCFT	Culverts and Road Crossings (Passage Barriers)	1, 3, 5	2A	5	0	0	0	0	0	0
PC-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT,	Dams and Surface Water Diversions	1, 3, 4	3B	5	91850	0	0	0	0	91850

		TBSLT, VWA, TCFT										
PC-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Dams and Surface Water Diversions	1, 3, 5	2A	5	91850	0	0	0	0	91850
PC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
PC-SCCCS-6.2	Develop and implement groundwater monitoring and management program	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, TCFT	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
PC-SCCCS-9.1	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1,3, 5	3B	100	0	0	0	0	0	0
PC-SCCCS-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
PC-SCCCS-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
PC-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Recreational Facilities	1, 2 , 3, 4, 5	3B	20	0	0	0	0	0	0
PC-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA,	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560

		TCFT										
PC-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, TCFT	Roads	1, 4	3B	20	0	0	0	0	0	0
PC-SCCC S-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	2345000	0	0	0	0	2345000
PC-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
PC-SCCC S-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
PC-SCCC S-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* San Simeon Community Service District Wastewater Treatment Facilities)	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
PC-SCCC S-15.1	Develop and implement an integrated wildlands fire and hazardous fuels plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Wildfires	1, 4, 5	2B	100	0	0	0	0	0	0

Table 12-8. South-Central California Steelhead DPS Recovery Action Table for the San Simeon Creek Watershed (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
San Simeon Creek												
SS-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
SS-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
SS-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
SS-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT	Agricultural Effluents	1, 4	2B	100	0	0	0	0	0	0
SS-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessments	NMFS, CDFG, CCCON, SLOC, TBSLT, VWA, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
SS-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, CDFG, CCCON, SLOC, TBSLT, VWA, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
SS-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	3B	5	91850	0	0	0	0	91850
SS-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA,	Dams and Surface Water Diversions		3B	5	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		TCFT										
SS-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, CCES,TCFT	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
SS-SCCCS-6.2	Develop and implement groundwater monitoring and management program	NMFS, USFS, USGS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
SS-SCCCS-7.1	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFG SLOC, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
SS-SCCCS-7.2	Develop and implement a stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFG SLOC, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
SS-SCCCS-8.1	Review and modify mining operations	USGS, NMFS, CDFG, CDMG, SLOC, CCRCDC, CSLRCD, NRCS, CCSE, TCFT	Mining and Quarrying	1, 3, 5	1B	20	68030	0	0	0	0	68030
SS-SCCCS-9.1	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, CCSE, TBSLT, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
SS-SCCCS-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, CCSE, VWA, CCSE, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
SS-SCCCS-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, CCSE, VWA, CSSE, TCFT	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SS-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.*, U.S. Forest Service Los Padres National Forest Land Management Plan, San Simeon State Beach Management Plan)	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
SS-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
SS-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Roads	1, 4	1B	20	0	0	0	0	0	0
SS-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Roads	1, 4	1B	20	32260	32260	32260	32260	0	129040
SS-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Roads	1, 4	1B	20	0	0	0	0	0	0
SS-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1675000	0	0	0	0	1675000
SS-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
SS-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE,TCFT	Urban Development	1,4	2B	5	62400	0	0	0	0	62400

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SS-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE, TCFT	Urban Development	1,4	2B	20	0	0	0	0	0	0
SS-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable stormwater permits	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
SS-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* Cambria Community Service District Wastewater Treatment Facilities)	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
SS-SCCCS-15.1	Develop and implement an integrated wildlands fire and hazardous fuels plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Wildfires	1,4, 5	2B	100	0	0	0	0	0	0

Table 12-9. South-Central California Steelhead DPS Recovery Action Table for the Santa Rosa Creek Watershed (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Santa Rosa Creek												
SR-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
SR-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
SR-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC,LPFW, TCLT, TBSLT, VWA, TCFT	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
SR-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
SR-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, TBSLT, VWA, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SR-SCCCS-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, CDFG, CCCON, SLOC, TBSLT, VWA, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)			5	0	0	0	0	0	0
SR-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 5	1A	5	91850	0	0	0	0	91850
SR-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, USFS, CDFG,SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Dams and Surface Water Diversions		2A	5	0	0	0	0	0	0
SR-SCCCS-5.1	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation	ACOE, NMFS, NRCS, SLOC, USGS, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Flood Control Maintenance	1, 4	1B	5	68030	0	0	0	0	68030
SR-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG, SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
SR-SCCCS-6.2	Develop and implement groundwater monitoring and management plan	NMFS, USFS, USGS, CDFG, SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
SR-SCCCS-7.1	Develop and implement plan to restore natural channel features	NRCS, FEMA, NMFS, CDFG SLOC, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SR-SCCC S-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFG SLOC, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
SR-SCCC S-7.3	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFG SLOC, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Levees and Channelization			100	0	0	0	0	0	0
SR-SCCC S-9.1	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, CCSE, VWA, TCFT	Non-Native Species	1,3, 5	3B	100	0	0	0	0	0	0
SR-SCCC S-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, CCSE, VWA, TCFT	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
SR-SCCC S-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, CCSE, VWA,TCFT	Non-Native Species	1, 3, 5	3B	20	0	0	0	0	0	0
SR-SCCC S-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* Shamel County Park)	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SR-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFG, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
SR-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Roads	1, 4	1B	20	32260	32260	32260	32260	0	129040
SR-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Roads	1, 4	1B	20	0	0	0	0	0	0
SR-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Roads	1,4	1B	5	4355000	0	0	0	0	4355000
SR-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, CDPR, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	62400	0	0	0	0	62400
SR-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
SR-SCCC	Develop, adopt, and implement urban land-use planning policies and	CCCOM, SLOC, NMFS, CDFG,	Urban Development	1,4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
S-13.1	standards	TCLT, TBSLT, VWA, CCSE,TCFT										
SR-SCCC S-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE,TCFT	Urban Development	1, 4	2B	20	0	0	0	0	0	0
SR-SCCC S-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
SR-SCCC S-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* Cambria Community Service District Wastewater Treatment Facilities)	RWQCB, SWRCB, SLOC, NMFS, CDFG, TCLT, TBSLT, VWA, CCSE, TCFT	Urban Effluents	1, 4	2B	100	0	0	0	0	0	0
SR-SCC-	Develop and implement an integrated wildland fire and hazardous fuel management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Wildfires	1, 4,	2B	20	0	0	0	0	0	0

Table 12-10. South-Central California Steelhead DPS Recovery Action Table for the Morro Creek Watershed (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Morro Creek												
MC-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
MC-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CCSE. CSLRDC, TCLT, CCSE, TCFT	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
MC-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CCSE. CSLRDC, TCLT, CCSE, TCFT	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
MC-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CSLRDC, CCSE,TCFT	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
MC-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
MC-SCCCS-3.2	Develop and implement a plan to remove or modify all identified fish passage barriers in the watershed	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A		0	0	0	0	0	0
MC-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
MC-SCCCS-4.2	Provide fish passage around dams and diversions	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
MC-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, SLOC, MB, USGS, CDFG, CCSE, TCFT	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
MC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG, SLOC, MB, CCSE, TCFT	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
MC-SCCCS-6.2	Develop and implement groundwater monitoring and management program	NMFS, USFS, USGS, CDFG, SLOC, MB, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
MC-SCCCS-7.1	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFG SLOC,MB, CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	2B	100	0	0	0	0	0	0
MC-SCCCS-7.2	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFG SLOC,MB, CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	2B	5	10521940	0	0	0	0	10521940
MC-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
MC-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
MC-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	76140	76140	76140	76140	0	304560
MC-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* Morro Bay State Park)	USFWS, NMFS, MB, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
MC-SCCCS-10.2	Develop and implement public education program on watershed processes	USFWS, NMFS, MB, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 5	2B	20	76140	76140	76140	76140	0	304560
MC-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	0	0	0	0	0	0
MC-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	32260	32260	32260	32260	0	129040
MC-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCFT	Roads	1,4	1B	20	0	0	0	0	0	0
MC-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFWS, NMFS, CDOT, SLOC, MB, CDPR, CDFGCCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5,	1A	5	2144000	0	0	0	0	2144000
MC-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, MB, NMFS,	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		CDFG, CCSE, TCFT										
MC-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, NMFS, CDFG, MB, CCSE,TCFT	Urban Development	1,4	2B	5	62400	0	0	0	0	62400
MC-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, NMFS, CDFG, MB, CCSE,TCFT	Urban Development	1,4	2B	20	0	0	0	0	0	0
MC-SCCCS-14.1	Review California Regional Water Quality Control Board Watersheds Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
MC-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* Morro bay/Cayucos Wastewater Treatment Facilities)	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1,4	2B	20	0	0	0	0	0	0
MC-SCCCS-14.3	Review, assess and modify residential and commercial wastewater septic treatment facilities	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	100	0	0	0	0	0	0
MC-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuel management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, CCSE, TCFT	Wildfires	1, 4	2B	100	0	0	0	0	0	0

Table 12-11. South-Central California Steelhead DPS Recovery Action Table for the Morro Bay Estuary (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Chorro Creek												
CC-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CCSE. CSLRDC, TCLT, CCSE, TCFT	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
CC-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CCSE. CSLRDC, TCLT, CCSE, TCFT	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
CC-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CCSE. CSLRDC, TCLT, CCSE, TCFT	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
CC-SCCCS-2.2	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CSLRDC, CCSE,TCFT	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
CC-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
CC-SCCCS-3.1	Develop and implement a plan to remove or modify fish passage barriers within the watershed	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
CC-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
CC-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
CC-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
CC-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, SLOC, MB, USGS, CDFG, CCSE, TCFT	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
CC-SCCCS-6.1	Conduct groundwater extraction analysis assessment	NMFS, USFS, USGS, CDFG, SLOC, MB, CCSE, TCFT	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
CC-SCCCS-6.2	Develop and implement groundwater monitoring and management program	NMFS, USFS, USGS, CDFG, SLOC, MB, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
CC-SCCCS-7.1	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFG SLOC,MB, CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	2B	100	0	0	0	0	0	0
CC-SCCCS-7.2	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFG SLOC,MB, CCRCDC,	Levees and Channelization	1, 4	2B	5	10521940	0	0	0	0	10521940

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		CSLRCD, CCSE, TCFT										
CC-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
CC-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
CC-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	76140	76140	76140	76140	0	304560
CC-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* Morro Bay State Park)	USFWS, NMFS, MB, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
CC-SCCCS-10.2	Develop and implement public education program on watershed processes	USFWS, NMFS, MB, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
CC-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	0	0	0	0	0	0
CC-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	32260	32260	32260	32260	0	129040

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
CC-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill or railroad lines and roads	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCF	Roads	1, 4	1B	20	0	0	0	0	0	0
CC-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFWS, NMFS, CDOT, SLOC, MB, CDPR, CDFGCCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	67000000	0	0	0	0	67000000
CC-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
CC-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, NMFS, CDFG, MB, CCSE,TCFT	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
CC-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, NMFS, CDFG, MB, CCSE,TCFT	Urban Development	1, 4	2B	20	0	0	0	0	0	0
CC-SCCCS-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	CCCOM, SLOC, NMFS, CDFG, MB, CCSE,TCF	Urban Development	1, 4	2B	5	398000	0	0	0	0	398000
CC-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable stormwater permits	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
CC-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* Los Osos Wastewater Treatment Facilities)	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
CC-SCCCS-14.3	Review, assess and modify residential and commercial wastewater septic treatment facilities	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	100	0	0	0	0	0	0
CC-SCSS-15.1	Develop and implement an integrated wildland fie and hazardous fuels management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, CCSE, TCFT	Wildfires	1, 4	2B	100	0	0	0	0	0	0
Los Osos Creek												
LO-SCCCS-1.1	Development, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CCSE. CSLRDC, TCLT, CCSE, TCFT	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
LO-SCCCS-1.2	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CCSE. CSLRDC, TCLT, CCSE, TCFT	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
LO-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, MB, CCRCDC, CSLRDC, CCSE, TCFT	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
LO-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
LO-SCCCS-3.1	Develop and implement a plan to remove or modify passage barriers in the watershed	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
LO-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
LO-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
LO-SCCCS-4.3	Provided fish passage around dams and diversions	NMFS, CDFG, CCCON, SLOC, MB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
LO-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, SLOC, MB, USGS, CDFG, CCSE, TCFT	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
LO-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG, SLOC, MB, CCSE, TCFT	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
LO-SCCCS-6.2	Develop and implement groundwater monitoring and management program	NMFS, USFS, USGS, CDFG, SLOC, MB, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
LO-SCCCS-7.1	Develop and implement plan to restore natural channel features	NRCS, FEMA, NMFS, CDFG SLOC,MB, CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	2B	100	0	0	0	0	0	0
LO-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or	NRCS, FEMA, NMFS, CDFG SLOC,MB, CCRCDC,	Levees and Channelization	1, 4	2B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
	minimize herbicide use near levees	CSLRCD, CCSE, TCFT										
LO-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
LO-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	76140	76140	76140	76140	0	304560
LO-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, MB, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	0	0	0	0	0	0
LO-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests	USFWS, NMFS, MB, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
LO-SCCCS-10.2	Develop and implement public education program on watershed processes	USFWS, NMFS, MB, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
LO-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCFT	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
LO-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCFT	Roads	1,4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
LO-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, MB, CDFG, CCSE, TCFT	Roads	1,4	2B	5	6700000	0	0	0	0	6700000
LO-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFWS, NMFS, CDOT, SLOC, MB, CDPR, CDFGCCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	62400	0	0	0	0	62400
LO-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5		5	62400	0	0	0	0	62400
LO-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, NMFS, CDFG, MB, CCSE,TCFT	Urban Development	1, 4	2B	20	0	0	0	0	0	0
LO-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, NMFS, CDFG, MB, CCSE,TCFT	Urban Development	1, 4	2B	20	0	0	0	0	0	0
LO-SCCCS-14.1	Review California Regional Water Quality Control Board Central Coast Region Basin Plans and modify applicable stormwater permits	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
LO-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* Los Osos Wastewater *Treatment* Facilities)	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
LO-SCCCS-15.1	Development and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW,	Wildfires	1.4	2B	5	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		CCSE, TCFT										

Table 12-12. South-Central California Steelhead DPS Recovery Action Table for the San Luis Obispo Creek (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
San Luis Obispo Creek												
SLO-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, CCLO, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
SLO-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NMFS, USFS, SLOC, CCLO, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
SLO-SCCCS-1.3	Manage agricultural development and restore riparian zones	NMFS, USFS, SLOC, CCLO, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
SLO-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, CSLO, CCRCDC, CSLRDC, CCSE,TCFT	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
SLO-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, CSLO, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
SLO-SCCCS-3.1	Develop and implement a plan to remove or modify passage barriers in the watershed (*e.g.,* San Luis Obispo County Stream Crossing Inventory and Fish Passage Evaluation, 2005;and San Luis Obispo Creek Watershed Enhancement Plan, 2002)	NMFS, CDFG, CCCON, SLOC, CSLO, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SLO-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFG, CCCON, SLOC, CSLO, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
SLO-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, CDFG, CCCON, SLOC, CSLO, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
SLO-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, CDFG, CCCON, SLOC, CSLO, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	TBD	TBD	TBD	TBD	TBD	TBD
SLO-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, SLOC, CSLO, USGS, CDFG, CCSE, TCFT	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
SLO-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG, SLOC, CSLO, CCSE, TCFT	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
SLO-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	NMFS, USFS, USGS, CDFG, SLOC, CSLO, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
SLO-SCCCS-7.1	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFG SLOC,CSLO, CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
SLO-SCCCS-7.2	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFG SLOC,CSLO, CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
SLO-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CSLO, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
SLO-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CSLO, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
SLO-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CSLO, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	76140	76140	76140	76140	0	304560
SLO-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests	USFWS, NMFS, CSLO, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 3, 4, 5	2B	20	0	0	0	0	0	0
SLO-SCCCS-10.2	Develop and implement public education program on watershed processes	USFWS, NMFS, CSLO, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
SLO-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CSLO, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	0	0	0	0	0	0
SLO-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CSLO, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	32260	32260	32260	32260	0	129040
SLO-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFG, USFS, CDOT, SLOC, CDPR, CSLO, CDFG, CCSE,	Roads	1, 4	1B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		TCFT										
SLO-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFWS, NMFS, CDOT, SLOC, CSLO, CDPR, CDFGCCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	4020000	0	0	0	0	4020000
SLO-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, MB, NMFS, CDFG, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	62400	0	0	0	0	62400
SLO-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, NMFS, CDFG, CSLO, CCSE,TCF	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
SLO-SCCCS-13.1	Retrofit storm drains in developed areas	CCCOM, SLOC, NMFS, CDFG, CSLO, CCSE,TCF	Urban Development	1, 4	2B	20	0	0	0	0	0	0
SLO-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, CSLO, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0
SLO-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* City of San Luis Obispo and Avila Wastewater Treatment Facilities)	RWQCB, SWRCB, SLOC, CSLO, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0
SLO-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, CCSE, TCFT	Wildfires	1. 4	2B	100	0	0	0	0	0	0

Table 12-13. South-Central California Steelhead DPS Recovery Action Table for the Pismo Creek (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Pismo Creek												
Pis-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, COPB, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
Pis-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat features	NRCS, BLM, NMFS, USFS, SLOC, COPB, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
Pis-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, COPB, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
Pis-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, COPB, CCRCDC, CSLRDC, CCSE,TCFT	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
Pis-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, COPB, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Pis-SCCCS-3.	Develop and implement plan to remove or modify fish passage barriers in the watershed (*e.g.,* San Luis Obispo County Stream Crossing Inventory and Fish Passage Evaluation, 2005)	NMFS, CDFG, CCCON, SLOC, COPB, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
Pis-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFG, CCCON, SLOC, COPB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Pis-SCCCS-4.2	Develop and implement water management plan for dam operations (*e.g.,* Righetti Dam on West Corral de Piedra Creek)	NMFS, CDFG, CCCON, SLOC, COPB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Pis-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, CDFG, CCCON, SLOC, COPB, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	TBD	TBD	TBD	TBD	TBD	TBD
Pis-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, SLOC, CPPB, USGS, CDFG, CCSE, TCFT	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
Pis-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG, SLOC, COPB, CCSE, TCFT	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
Pis-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	NMFS, USFS, USGS, CDFG, SLOC, COPB, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
Pis-SCCCS-7.1	Develop and implement plan to restore natural channel features	NRCS, FEMA, NMFS, CDFG SLOC,COPB, CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
Pis-SCCCS-	Develop and implement plan to vegetate levees and eliminate or minimize	NRCS, FEMA, NMFS, CDFG	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
7.2	herbicide use near levees	SLOC,COPB, CCRCDC, CSLRCD, CCSE, TCFT										
Pis-SCCCS-7.3	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFG SLOC,COPB, CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
Pis-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, CSLO, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
Pis-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, CSLO, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	76140	76140	76140	76140	0	304560
Pis-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, CSLO, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	0	0	0	0	0	0
Pis-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (e.g., Pismo State Beach)	USFWS, NMFS, COPB, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
Pis-SCCCS-10.2	Develop and implement public education program on watershed processes	USFWS, NMFS, COPB, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
Pis-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, CDOT, SLOC, CDPR, COPB, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	32260	32260	32260	32260	0	129040

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Pis-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFG, CDOT, SLOC, CDPR, COPB, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	0	0	0	0	0	0
Pis-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and road	USDOT, NMFS, CDFG, CDOT, SLOC, CDPR, COPB, CDFG, CCSE, TCFT	Roads	1, 4	1B	5	3082000	0	0	0	0	3082000
Pis-SCCCS-12.1	Develop and implement an estuary restoration and management	USFWS, NMFS, CDOT, SLOC, COPB, CDPR, CDFGCCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
Pis-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, COPB, NMFS, CDFG, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	62400	0	0	0	0	62400
Pis-SCCCS-13,1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, NMFS, CDFG, COPB, CCSE,TCF	Urban Development	1, 4	1B	20	0	0	0	0	0	0
Pis-SCCCS-13,2	Retrofit storm drains in developed areas	CCCOM, SLOC, NMFS, CDFG, COPB, CCSE,TCF	Urban Development	1, 4	1B	5	398000	0	0	0	0	398000
Pis-SCCCS-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	CCCOM, SLOC, NMFS, CDFG, COPB, CCSE,TCF	Urban Development	1, 4	1B	20	0	0	0	0	0	0
Pis-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable stormwater permits	RWQCB, SWRCB, SLOC, COPB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Pis-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* Pismo Beach Wastewater Treatment Facility and Cypress Ridge Wastewater Treatment Facility)	RWQCB, SWRCB, SLOC, COPB, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	1B	100	0	0	0	0	0	0
Pis-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuel management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, CCSE, TCFT	Wildfires	1, 4	2B	20	0	0	0	0	0	0

Table 12-14. South-Central California Steelhead DPS Recovery Action Table for the Arroyo Grande Creek (San Luis Obispo Terrace BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Arroyo Grande Creek												
AG-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, AG, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
AG-SCCCS-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, AG, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
AG-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, AG, CCRCDC, CCSE. CSLRDC, CCSE, TCFT	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
AG-SCCCS-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, AG, CCRCDC, CSLRDC, CCSE,TCFT	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
AG-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFG, CCCON, SLOC, AG, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)			5	96690	0	0	0	0	96690

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
AG-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers in the watershed (*e.g.,* San Luis Obispo County Stream Crossing Inventory and Fish Passage Evaluation, 2005)	NMFS, CDFG, CCCON, SLOC, AG, CCSE, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
AG-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS**, CDFG, CCCON, SLOC,** AG**, CCSE, TCFT**	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
AG-SCCCS-4.2	Develop and implement water management plan for dam operations (e.g., Lopez Dam)	NMF**S, CDFG,** CCCON**, SLOC,** AG**, CCSE, TCFT**	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
AG-SCCCS-4.3	Provide fish passage around dams and diversions	NMFS, **CDFG,** CCCON**, SLOC,** AG**, CCSE, TCFT**	Dams and Surface Water Diversions	1, 3, 4	1A	10	TBD	TBD	TBD	TBD	TBD	TBD
AG-SCCCS-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, SLOC, AG, USGS, CDFG, CCSE, TCFT	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
AG-SCCCS-6.1	Conduct groundwater extraction analysis and assessment	NMFS, USFS, USGS, CDFG, SLOC, AG, CCSE, TCFT	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
AG-SCCCS-6.2	Develop and implement a groundwater monitoring and management program	NMFS, USFS, USGS, CDFG, SLOC, Ag, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
AG-SCCCS-7.1	Develop and implement plan to restore natural channel features	NRCS, FEMA, NMFS, CDFG SLOC, AG , CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
AG-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFG SLOC, AG , CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
AG-SC3S-7.2	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFG SLOC, AG , CCRCDC, CSLRCD, CCSE, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
AG-SCCCS-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFG, CDPR, AG, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
AG-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFG, CDPR, AG, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	76140	76140	76140	76140	0	304560
AG-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFG, CDPR, AG, CNPS, CCSE,TCFT	Non-Native Species	1, 3, 4	2B	20	0	0	0	0	0	0
AG-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.,* Pismo Dunes Natural Preserve Management Plan)	USFWS, NMFS, AG, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
AG-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, NMFS, AG, CDFG, CDPR, CNPS, CCSE, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
AG-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFG, CDOT, SLOC, CDPR, AG, CDFG,	Roads	1, 4	1B	20	32260	32260	32260	32260	0	129040

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
		CCSE, TCFT										
AG-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFG, CDOT, SLOC, CDPR, AG, CDFG, CCSE, TCFT	Roads	1, 4	1B	20	0	0	0	0	0	0
AG-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFG, CDOT, SLOC, CDPR, AG, CDFG, CCSE, TCFT	Roads	1,4	1B	5	6097000	0	0	0	0	6097000
AG-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFWS, NMFS, CDOT, SLOC, AG, CDPR, CDFGCCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	62400	0	0	0	0	62400
AG-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, AG, NMFS, CDFG, CCSE, TCFT	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
AG-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, NMFS, CDFG, AG, CCSE,TCF	Urban Development	1, 4	2B	20	0	0	0	0	0	0
AG-SCCCS-13.2	Retrofit storm drains in developed areas Add an additional recovery action:	CCCOM, SLOC, NMFS, CDFG, AG, CCSE,TCF	Urban Development	1, 4	2B	5	398000	0	0	0	0	398000
AG-SCCCS-13.2	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	CCCOM, SLOC, NMFS, CDFG, AG, CCSE,TCF	Urban Development	1, 4	2B	20	0	0	0	0	0	0
AG-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, AG, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
AG-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* South San Luis Obispo Sanitation District Wastewater Treatment Facility and Cypress Ridge Wastewater Treatment Facility)	RWQCB, SWRCB, SLOC, AG, NMFS, CDFG, CCSE, TCFT	Urban Effluents	1, 4	2B	100	0	0	0	0	0	0
AG-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFG, LPFW, CCSE, TCFT	Wildfires	1, 4	2B	20	0	0	0	0	0	0

13. South-Central California Coast Steelhead Research, Monitoring, and Adaptive Management

"The analytic tools to evaluate species health have been greatly developed in recent years. The emergence of extinction theory from population genetics and ecology, the combination of demography and genetics in population viability analysis and the extension of risk analyses into the realm of biological conservation promises to lead us to wiser allocations of effort in the future."

Science and the Endangered Species Act, National Research Council, 1995

13.1 INTRODUCTION

Recovery of South-Central California steelhead will require a more thorough understanding of the distinctive biology of steelhead within the SCCCS Recovery Planning Area. Additionally, it is crucially important to identify a program for monitoring the status of individual populations and the DPS as a whole, and a plan for tracking and adjusting the recovery actions and recovery strategy over an extended period to optimize the effectiveness of the recovery effort. The following sections outline the basic elements of a research, monitoring, and adaptive management program, and identify high priority research and monitoring actions.

13.1.1 South-Central California Steelhead Research

In 2002 NMFS convened a team of scientific specialists, the Technical Review Team (TRT), whose mission was to survey existing scientific information on steelhead ecology, and formulate a biological framework for a recovery plan for South-Central California steelhead (Boughton *et al.* 2007b, 2006, Boughton and Goslin 2006, Boughton *et al.* 2005, Boughton and Fish 2003).

The current state of knowledge of steelhead ecology is largely descriptive and qualitative. This has led to uncertainties in the viability framework, including developing quantitative goals for distribution and abundance of steelhead trout and general strategies for how to achieve these goals. In general, the TRT approached uncertainty about recovery goals with a risk-averse, or precautionary, stance, consistent with accepted practice in conservation biology (McElhany *et al.* 2000). The

TRT also recognized that key uncertainties involved in recovery planning arose from the qualitative nature of the current understanding, and could be improved by a carefully conceived and planned program of scientific research and monitoring. The benefits of pursuing such a program would be a more effective, and more-cost efficient, recovery effort for steelhead.

Recovery of South-Central California steelhead will depend upon a quantitative framework that addresses their annual run size, along with year-to-year variability over the long term; and the quantitative response of steelhead runs to specific recovery actions. These are related to the two overarching questions of steelhead recovery in this region:

- How do we improve the distribution, abundance, and resilience of steelhead trout populations; and
- How much do we need to improve these biological characteristics for steelhead to be considered viable and eligible for down-listing and/or delisting?

The following sub-sections focus on the viability criteria developed by the TRT, and a series of related research questions grouped into three areas: enhancing anadromy, clarifying the population structure of *O. mykiss*, and planning for climate change.

13.2 VIABILITY CRITERIA

The viability criteria address two levels of biological organization, populations within the Distinct Population Segment (*i.e.,* only the anadromous form), and the more encompassing Evolutionarily Significant Unit (ESU), which includes all life history forms. The *O. mykiss* ESUs in this Recovery Planning Area are composed of both anadromous and non-anadromous fish, but only the non-anadromous form is on the threatened species list, under the DPS provision of the Federal Endangered Species Act. One of the principal uncertainties is the complicated relationship between the anadromous and non-anadromous (or freshwater-resident) forms of the species. Following convention, the term "steelhead trout" is used for the anadromous fish, "rainbow trout" for non-anadromous fish, and "*O. mykiss*" when referring to both or either. The goal of the Recovery Plan is to ensure the continued persistence of steelhead trout in the region over the long term (Boughton *et al.* 2007b), but it is likely that rainbow trout have some role in securing this future, and thus the viability criteria have provisions for both forms of the species.

13.2.1 Population-Level Criteria

The TRT considered *O. mykiss* in the region to be grouped into demographically - independent populations. Generally, each discrete coastal watershed in the region was assumed to have historically supported one demographically independent population of *O. mykiss.* If migratory steelhead frequently move from one watershed to another, the one-watershed-one-population assumption may have some important exceptions with implications for recovery planning.

The TRT proposed population-level viability criteria for determining whether a demographically- independent population of *O. mykiss* should be considered viable for the purpose of steelhead recovery. The TRT identified two choices for meeting the viability criteria. The first was to meet a set of criteria: a population must exhibit a mean annual run size of at least 4,150 steelhead trout, including during periods of poor ocean conditions (such as occurred from the late 1970s through early 1990s). Additionally, the spawner densities in the river systems needed to meet a minimum density threshold (fish per kilometer of stream channel at some scale), a quantitative criterion yet to be determined. The second choice was to meet a performance-based criterion, demonstrating that the extinction risk for steelhead trout is less than 5% over 100 years,

using commonly accepted quantitative methods from conservation biology, demographic data from the population in question, and passing an independent scientific review.

Extinction risk is very sensitive to both annual run size and year-to-year variability. As a result, the performance-based criteria cannot be applied in a meaningful way until run sizes have been monitored for a decade or more, allowing this key quantity to be estimated with reasonable accuracy. In the interim, the prescriptive criteria ensures that the year-to-year variability in run size, whatever its probable magnitude, is unlikely to pose a significant risk to the species. If year-to-year variability turns out to be relatively modest, a mean run size smaller than 4,150 steelhead would perhaps be sufficient to ensure a low extinction risk. Including the option for performance-based viability criteria, provides a mechanism for refining the viability criteria as more is learned over time.

Extinction risk for individual steelhead runs may also be sensitive to the influence of rainbow trout, if the trout tend to stabilize or augment those runs as a result of rainbow trout regularly producing anadromous progeny. This phenomenon is referred to as "life history crossovers," but it is not yet known whether such crossovers occur frequently enough to stabilize steelhead runs. This is another key uncertainty that, if resolved, might allow the run-size criterion of 4,150 spawners per year to be adjusted. In this case, the adjustment would be that some fraction of the 4,150 spawners within a watershed or metapopulation would need to exhibit the anadromous life history, rather than 100%. Additionally, data on the magnitude of natural fluctuations in anadromous run sizes in individual watersheds may identify a smaller mean run size is sufficient for viability in some basins (Williams *et al.* 2011). Until such research is undertaken and revisions made to the viability criteria, the population-level viability criteria for determining whether a demographically-independent population of *O. mykiss* should be considered viable for the purpose of steelhead recovery would remain 4,150. This criteria will be reviewed during NMFSs 5-year review of the Recovery Plan, and potentially during the Southwest Fisheries Science Center's 5-year status review update for Pacific salmon and steelhead listed under the ESA..

In the absence of specific information about the role of life history crossovers, the TRT took a precautionary approach (*i.e.,* it was assumed there was not any beneficial effect of crossovers). This meant that the 4,150 spawners per year required for viability must be composed entirely of steelhead trout, rather than a mixture of rainbow and steelhead to ensure viability. However, the TRT also believed that the criteria should cover the possibility that the beneficial effect of crossovers not only exists, but is necessary for viability of the listed species. This led to additional criteria that the anadromous and freshwater resident life history types should both be expressed in populations for them to be considered viable.

It would be useful to learn whether rainbow trout significantly enhance or stabilize steelhead runs. If rainbow trout progeny crossover does in fact have a beneficial effect on steelhead runs - and its magnitude can be quantified - such knowledge could be used to revise the criteria for anadromous fraction criteria, or it could be incorporated into a performance-based assessment of risk, possibly resulting in different run size and anadromous fraction criteria. Research into these topics is essential to resolve these issues in a way which maintains acceptably low extinction risk to the species.

13.2.2 ESU/DPS-Level Criteria

The TRT outlined a set of ESU/DPS-level criteria, which, if met, would indicate that a steelhead Distinct Population Segment has been successfully recovered. Satisfying the ESU/DPS-level criteria requires a set of *O. mykiss* populations in which:

- Each population satisfies the population-level criteria described above, and
- The set of populations as a whole satisfies requirements for ecological representation and redundancy, and
- The set of populations as a whole exhibit all three life history types (fluvial-anadromous, lagoon-anadromous, freshwater resident)

The criteria for representation and redundancy have two purposes. First, to protect the genetic and ecological diversity that ensures the long-term viability of the species under changing conditions, the set of populations should represent the entire range of ecological and genetic conditions originally present in the ESU/DPS. Second, to protect against catastrophic loss of entire populations due to disease, forest fires, drought, *etc.*, the set of populations should exhibit redundancy with respect to the range of ecological and genetic conditions originally present in the ESU. This ensures that if, for example, entire populations are lost from a particular ecotype, there will be at least one other population in that ecotype that survives, and can serve as a reservoir of individuals retaining the genetic and phenotypic adaptations necessary for inhabiting that ecotype. Ultimately, such individuals would be necessary for recolonizing the watersheds.

The TRT developed criteria for representation and redundancy by grouping the region's populations of *O. mykiss* into biogeographic groups, and specifying a minimum level of redundancy (number of viable populations) within each group. In addition, the TRT recommended that the core populations should inhabit watersheds with drought refugia, should be separated from one another by at least 42 miles if possible, and should exhibit three life history types—the rainbow trout form described previously, and two forms of steelhead trout, the lagoon-anadromous form and the fluvial-anadromous form.

The biogeographic groups were delineated on the basis of geographic proximity, broadly similar climate, and aspects of physiography that are relevant to the fish (see Table 5 and Figure 5 in Boughton *et al.* 2007b). Summer air temperatures, which strongly influence whether summer stream temperatures are cool enough for the fish, were a key consideration. The most important split was between coastal groups of populations, in which cool mesoclimates are maintained by proximity to the ocean, and interior groups of populations, where cool mesoclimates are primarily confined to mountain ranges, and are maintained by the temperature lapse rate (i.e. the reduction in temperature with increased elevation).

The criteria for redundancy within each biogeographic group were based on an assessment of catastrophic risks posed by wildfires and debris flows. However, the assessment was based on historical pattern and did not include considerations of climate change, which could have a large impact on the region. See Chapter 5, South-Central California Steelhead and Climate Change.

The TRT also considered the catastrophic risk posed by drought, but could not incorporate it into the criteria due to insufficient information. The broad spatial extent of the typical drought in the region indicated that simple redundancy was not a suitable strategy for protecting the species from its effects. Watersheds having potential as drought refugia—stream systems that maintain suitable summer baseflows and water temperatures during severe multi-year droughts – should be identified and protected.

The broad-scale climatic factors that control the distribution of *O. mykiss* in the region appear to be summer air temperatures, annual precipitation, and the severity of winter storms, the last having its effect by determining the power of high flow events that organize the

distribution and extent of in-stream steelhead habitat. All of these factors are likely to undergo a long-term shift as part of CO_2-induced climate change. In addition, the region's frequent wildfires strongly influence the sediment budgets of streams, and thus the distribution of steelhead habitat. The overall wildfire regime is also likely to undergo a permanent shift in response to climate change. The magnitudes of these shifts, and the magnitude of their direct and interaction effects on stream habitat, are not yet clear. Thus a key uncertainty is how to plan for climate change both at the level of the ESU and individual stream watersheds.

13.3 RESEARCH FOCUS: ANADROMY, POPULATION STRUCTURE, AND MONITORING STEELHEAD RECOVERY

The natural dynamics of watersheds and stream systems maintain steelhead habitat in the recovery planning area in a stochastic, dynamic equilibrium. This equilibrium can involve dramatic processes such as floods and forest fires that disrupt habitat in the short term but ensure its continued existence over the long term. Other processes that circumscribe the productivity of freshwater steelhead habitat, such as the severity of the dry season or the pattern of high-flow events during the wet season, may affect reproductive success. These ecological constraints are generally understood at a qualitative level, but this level of knowledge is, in some cases, too vague to provide specific guidance for setting goals and choosing specific recovery actions. The research program supporting steelhead recovery in this region should focus on quantitative studies that: 1) identify ecological factors that promote anadromy; 2) clarify key aspects of population structure; and 3) monitor progress toward recovery. Many of these research activities could be carried out within the context of the California Coastal Salmonid Population Monitoring Program (Adams *et al.* 2011).

13.3.1 Identify Ecological Factors that Promote Anadromy

The primary focus of this Recovery Plan - to recover and secure the anadromous form of *O. mykiss* - involves restoring ecological conditions that specifically promote the population growth and abundance of the anadromous form.

While it is necessary to have migration corridors for steelhead to reach a spawning area, this does not necessarily imply that anadromous forms will out-compete the freshwater residents that spawn in the same area. At present it is not clear what ecological conditions specifically promote the sea-going form over the resident form though there are some important clues. These clues present a prime opportunity for research that would lead to more effective recovery actions.

Anadromous females exhibit a large fecundity advantage over their resident counterparts. As shown in Figure 14-1, an adult female's egg production increases exponentially with body length, and adult *O. mykiss* are generally able to attain much larger sizes in the ocean than in freshwater.

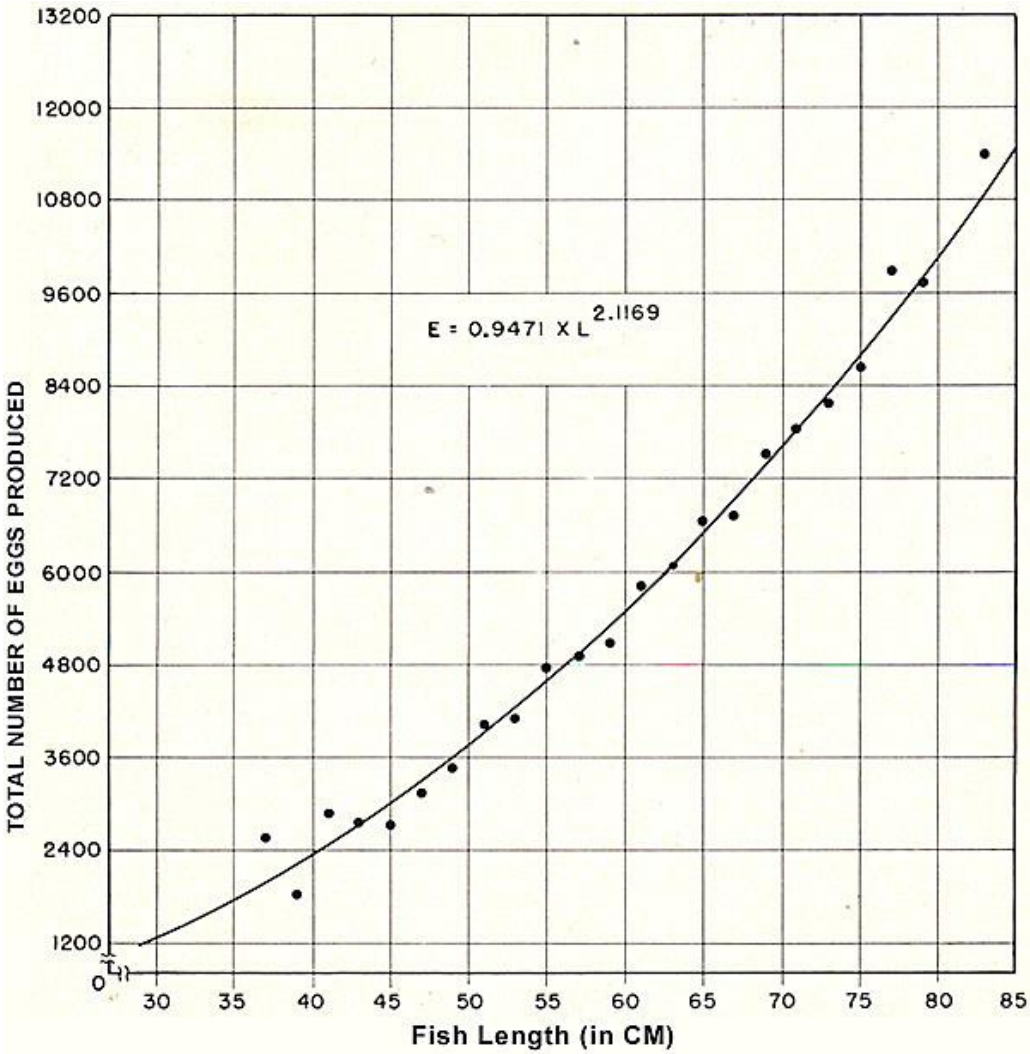


Figure 13-1. Fecundity as a function of body size for female steelhead sampled from Scott Creek in Santa Cruz County. Reproduced from Shapovalov and Taft (1954).

Thus, a typical female rainbow trout might attain a length of 35 cm, enabling her to produce 1800 eggs annually, whereas a medium sized steelhead female at 60 cm could produce over 3.5 times that number. This factor alone gives the sea-going form a distinct advantage and, all else being equal (and assuming the two forms breed true), over time the sea-going form should come to dominate any stream system with migration connectivity to the ocean. The resident forms would become confined to streams that lack migration connectivity. This pattern has been observed, for example, in the Deschutes River in Oregon (Zimmerman and Reeves 2000).

In South-Central California, three ecological factors could potentially counteract this size advantage so that the resident form is sometimes favored in anadromous waters. First, the migration corridor between the ocean and freshwater habitat could be unreliable. Second, mortality may sometimes be much higher in the ocean than in freshwater, counteracting the potential size advantage of sea-going fish. Third, juveniles of the freshwater form may survive better or compete better in freshwater than

juveniles of the sea-going form, which could also counteract the natural size/fecundity advantage of the sea-going form. Of these three possibilities, the first two are supported by various lines of evidence, and the third has some suggestive evidence. The need is to move beyond existing evidence to a quantitative understanding of ecological mechanism, so that specific recovery strategies can be linked to desired outcomes.

13.3.2 Reliability of Migration Corridors

Question: What is the relationship between reliability of migration corridors, and anadromous fraction?

Discussion: Migration corridors in this arid region are clearly unreliable, but it is not clear precisely how reliable they must be for the anadromous form to persist over the long term, nor how to best characterize reliability.

Recommendation: The relationship between flow patterns in managed rivers, the reliability of migration opportunities, and the long term persistence of steelhead runs is likely to be watershed specific, but could be characterized through the establishment of a long-term monitoring effort that tracks abundance and timing of steelhead runs, and the timing of smolt runs, in specific watersheds of interest. This would provide a framework by which management actions, in the form of managed flow regimes, could be related to outcomes, in the form of migrant abundance and timing. However, answers would probably emerge only over the long term, and numerous confounding factors would also need to be taken into account by the monitoring framework.

13.3.3 Steelhead-Promoting Nursery Habitats

Question: What nursery habitats promote rapid growth rates of juveniles (and therefore larger size) at the time smolts emigrate to the ocean?

Discussion: Marine survival varies among salmonids, ranging from 25% to below 1% (Welch *et al.* 2009, Logerwell *et al*. 2003, Peterson and Schwing, 2003, Ward 2000, Ward *et al*. 1989). Improving the marine survival rate of steelhead would be beyond the scope of most management strategies, since steelhead are rarely fished and other sources of ocean mortality are largely uncontrollable. However, mortality rates of many marine fishes are strongly size-dependent. Consistent with this general pattern, young steelhead migrating to the sea tend to survive much better if they have a larger size at ocean entry (Hayes, *et al.* 2008, Bond, 2006, Ward *et al*. 1989). Thus, their growth opportunities in freshwater may influence their subsequent marine survival.

Figure 13-2, indicates that an outgoing smolt that has a fork length of 14 cm has about a 3% chance of surviving to spawn, but a 16.5 cm smolt's chances are at least 3.5 times better (*c.* 10%), and a 22 cm smolt's chances are an order of magnitude better (37%). Thus, the mortality effects of size at ocean entry can be of the same order as the fecundity advantages of migrating to the ocean in the first place.

A similar relationship between survival and size at ocean entry was observed by Bond (2006) and Hayes *et al*. (2008) in Scott Creek in Santa Cruz County, which is much closer geographically to South-Central California. Size at ocean entry appears to be at least as important as final spawning size in modulating the relative abundances of the freshwater and ocean-going forms of *O. mykiss.* [1]

[1] Its importance can vary over time, however. Ward (2000) observed that after 1989, marine survival drastically declined in the Keogh River population, and the relationship disappeared between marine survival and size at ocean entry. This was attributed to a change in ocean conditions, and indicates that the survival advantage of being a large smolt varies over time.

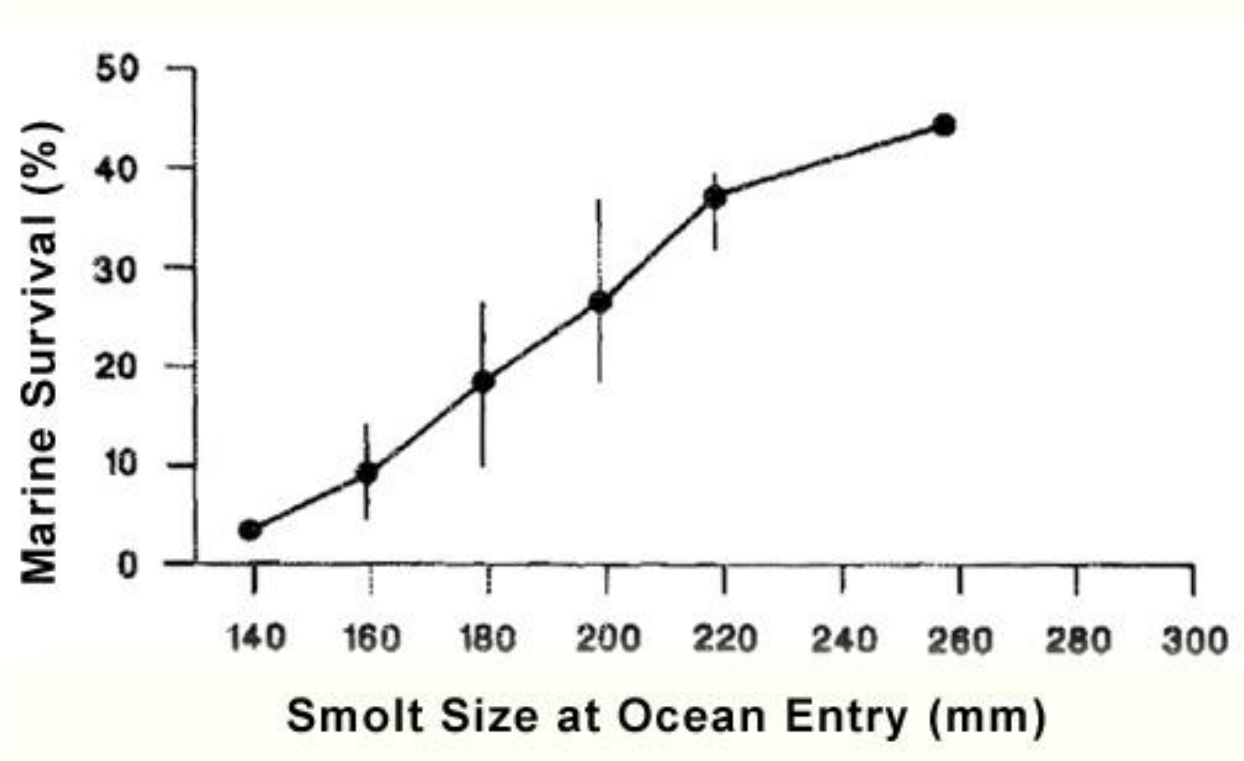


Figure 13-2. Marine survival of steelhead as a function of body size at ocean entry, in the Keogh River steelhead population described by Ward *et al*. (1989). Figure depicts the average survival to spawning of smolts emigrating in years 1977 - 1982.

High quality steelhead nursery habitats might develop where cool-water habitats receive large terrestrial inputs of food items. Terrestrial insects often fall in the water (Harvey *et al.* 2002, Douglas *et al.* 1994), and can provide a significant component of the diet of young steelhead (Rundio 2009, Rundio and Lindley, 2008). The study by Rundio and Lindley (2008) in the Big Sur area found terrestrial insects were sporadic in the diet of *O. mykiss*, but each item had large mass and thus was highly nutritious for the fish. Habitats with more frequent inputs of terrestrial insects would afford larger growth opportunities.

Finally, some habitats might produce rapid growth if there is a mechanism to keep juvenile densities low, so that individuals have expanded feeding opportunities. For example, it might be the case that intermittent streams provide expanded feeding opportunities during their wet season, because their dry season prevents the establishment of a large permanent population of resident rainbow trout. Overall, this suggests that the recovery prospects for steelhead runs would be significantly improved by identifying, restoring, and protecting those freshwater habitats that tend to produce large smolts, as part of the overall recovery strategy. These areas would qualify as steelhead "nursery habitats," defined as juvenile habitats that produce adult recruits out of proportion to their spatial extent relative to other habitats (Beck *et al.* 2001).

Recommendation: The identification and restoration of steelhead nursery habitats is a prime research opportunity with large potential

for enhancing steelhead recovery efforts. Nursery habitats would likely be estuarine or freshwater habitats that support rapid growth of young fish during the first or possibly second year of life, since large body size of migrants at ocean entry substantially improves their subsequent survival in the ocean. The simplest type of study to identify such habitats would be to use mark-recapture techniques to track growth and survival of juveniles as a function of habitat use. A more complete study would also track the consequences for marine survival.

13.3.4 Comparative Evaluation of Seasonal Lagoons

Question: What role do seasonal lagoons play in the life history of steelhead, and in particular, to what extent are seasonal lagoons used as nursery areas and promote the growth of juveniles prior to emigration to the ocean as smolts? What specific ecological factors contribute to lagoon suitability steelhead rearing (survival, growth)? What ecological factors contribute to the persistence of those lagoon features?

Discussion: One type of steelhead nursery habitat is the freshwater lagoons that form in the estuaries of many stream systems during the dry season. In some of these seasonal lagoons, juvenile steelhead can grow very quickly and enter the ocean at larger sizes, where they survive relatively well and thus contribute disproportionately to returning runs of spawners (Bond, 2006). Smith (1990), however, has observed that some lagoons can be quite vulnerable to rapid degradation in quality, and others may never be suitable, due to local environmental factors that can produce anoxic conditions or poor feeding opportunities. The existing information on the role of lagoons mostly comes from Santa Cruz County, and is focused only on a few systems. As described above, this work suggests that lagoons can comprise steelhead nursery habitat, but can also be vulnerable to various natural and anthropogenic disturbances (Smith, 1990). There is a need to determine which lagoons have the potential to play a positive role in anadromy-targeted recovery efforts.

Seasonal lagoons are a specific kind of estuary and in general, estuaries are highly dynamic interfaces between two other much larger ecosystems: freshwater stream networks on the terrestrial side, and the ocean ecosystem on the marine side. This accounts for estuaries' dynamism, complexity, and sensitivity to external influences, but also for much of their productivity (Hofmann, 2000; Jay *et al.* 2000). Although there appears to be a general unity in function of many of the small estuaries in our region (due to the general similarity of climate, terrestrial watershed conditions, and the raised coast), there is also much variation and one would expect that small differences in, say, watershed condition or coastal wind and current patterns, would sometimes translate into large differences in the suitability of lagoons as steelhead nursery habitat (Rich and Keller 2011).

Recommendation: Comparative studies on the environmental controls for productivity and reliability of lagoon habitat (including how to restore it if necessary) would aid in identifying those estuaries capable of serving as reliable steelhead nursery habitat. Such studies should focus on factors enabling rapid growth of juvenile steelhead, and factors conferring resiliency against catastrophic failure of habitat quality (anoxia, premature breaching, *etc.*).

13.3.5 Potential Nursery Role of Mainstem Habitats

Question: What role do mainstem habitats play in the life history of steelhead, and in particular, to what extent are they used as nursery areas and promote the growth of juveniles prior to emigration to the ocean as smolts? What specific ecological factors contribute to mainstem quality (survival, growth) for steelhead rearing? What ecological factors contribute to mainstem reliability?

Discussion: There may be other freshwater habitats that support high survival and robust growth of juveniles, and so constitute nursery habitat specifically for the anadromous form of the species. Low-gradient mainstem habitats, such as the trunks of the Pajaro and Salinas Rivers may also have once supported rapid growth of juveniles, particularly if reaches received enough sunlight to support primary productivity, but artesian flows or other groundwater inputs kept water cool in the summer (C. Swift, personal communication). Most mainstem habitats have now been highly altered by agricultural clearing and groundwater pumping, so an effort to determine their potential to contribute to steelhead recovery would require a focused effort.

Recommendation: The potential nursery role of mainstem habitat is much more speculative than the nursery role of lagoons. Initial assessment of the potential nursery role could take the form of 1) empirical study of mainstem habitat use by juvenile steelhead, at broad and fine scales; and 2) water-temperature modeling that accounts for effects of climate, insolation, and groundwater interaction on mainstem water temperatures, especially during the summer. The empirical work would be most useful if it applied mark-recapture techniques to assess growth and survival as a function of habitat use, and in managed rivers, as a function of the flow regime.

13.3.6 Potential Positive Roles of Intermittent Creeks

Question: Do intermittent creeks, serving as steelhead nursery habitat, positively influence the anadromous fraction of *O. mykiss* populations, or otherwise enhance viability of the anadromous form of the species?

Discussion: Juvenile *O. mykiss* are common in intermittent creeks (Boughton *et al*. 2009), but it is unclear whether these only function as sink habitat (a net drain on productivity) or play a more positive role in population viability. Boughton *et al.* (2009) observed that during the early summer in a moderately wet year, densities of young-of-the-year *O. mykiss* were nearly identical in the perennial and intermittent creeks of the Arroyo Seco watershed in Monterey County. Much of the intermittent creeks dried up and killed juveniles later in the summer, and indeed such mortality has been observed in the region for many years (Shapovalov, 1944), although it is also common to find scattered residual pools or reaches packed with fish in late summer. For example, Spina *et al.* 2005 observed fish in San Luis Obispo creek moving into sections of the stream network retaining perennial flow as other streams dried out over the summer months. The important issue for recovery purposes is identifying the potential positive, rather than negative, roles of intermittent creeks in sustaining the viability of steelhead populations.

The most obvious positive role is that intermittent creeks provide migration corridors to perennial creeks during the wet season. Perennial reaches often occur in low-order streams upstream of intermittent sections, so the corridor role increases the amount of accessible perennial habitat, and thus the size of the steelhead population that can be supported. In dry years, the corridor function would fail in some areas.

Boughton *et al*. (2009) found that most spawning habitat in the Arroyo Seco system tended to occur in intermittent streams, and argued that hydrologic and geomorphic processes would tend to produce such a pattern in general. This suggests a second positive function of intermittent streams—significantly expanding the amount of spawning habitat beyond what is available in perennial streams—but it also suggests a need for an additional corridor function. In this case, the corridor function is for young-of-the-year to emigrate to perennial reaches before the summer dry season traps and kills them.

It is possible that intermittent streams enable a high-risk, high-reward strategy on the part of young steelhead. Many individuals may be killed during the summer drying season, but those surviving in the residual pools may benefit from enhanced growth. One mechanism for enhanced growth may be cannibalism of trapped cohorts. Another mechanism for rapid growth may be rapid recolonization of the dried stream channels as flows become re-established with cooler, wet weather in the fall.[2] Such fish would find few competitors, and perhaps even an enhanced opportunity to feed on eggs and fry of the following winter's spawners (Ebersole *et al.* 2006). In this manner, intermittent creeks could serve as steelhead nursery habitat

In wet years, the seasonal drying may be substantially reduced, increasing summer survival and allowing large pulses of juveniles to be recruited to the subpopulation of adult steelhead in the ocean. Under some scenarios, such as a highly plastic life history strategy (see next section), it is possible that such pulses would be the primary mode of production for anadromous individuals, and sustain the anadromous form of the species over the long term.

Recommendation: Intermittent creeks comprise a large proportion of freshwater *O. mykiss* habitat in the region. Despite an obvious negative role in the species ecology, they may have important positive roles as well. These potentially positive roles have the status of hypotheses with general implications for recovery strategies and viability targets, and should be tested.

[2] Fall rains can re-establish flows, but flows may also be re-established by cooler fall weather, which presumably lowers transpiration demands of riparian vegetation, leaving more groundwater to maintain base flows in stream channels.

13.3.7 Spawner Density as an Indicator of Viability

Question: What spawner density (at what spatial and temporal scale) is sufficient to indicate a viable population of steelhead?

Discussion: Answering this question requires that one or more robust anadromous populations be carefully characterized. The answer is more useful in the long-term, as an indicator of progress toward recovery, than it is in the short term for achieving recovery. The most useful data would be a time-series of observations of spawner density over many years.

Recommendation: Monitor a select number of core and non-core populations to determine the numbers of spawners using both mainstem and tributary spawning habitats.

13.3.8 Clarify Population Structure

Population structure concerns the ecological and biological factors that cause fish to naturally group into functional units known as independent populations. Independent populations are defined as "a collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations" (McElhany *et al*. 2000).

If groups of fish regularly exchange individuals, they are members of the same population, whereas if exchange is rare or does not significantly affect population dynamics, they are members of separate populations. This definition of "separateness between, exchange within" means that the proper context of most management strategies is the independent population: a strategy that directly affects only a portion of a population will soon have significant indirect effects on the rest of the

population, but few immediate effects on other populations. [3]

The independent population is also the fundamental functional unit of species persistence, and hence viability. As a result, many of the viability criteria described by Boughton *et al.* (2007b) were defined in terms of population traits such as anadromous fraction and mean spawner abundance over time. The collections of fish to which these criteria should be applied are a function of what is known about the patterns of exchange of fish among breeding biological units. Open questions about such exchange result in uncertainty about how to apply the criteria.

Thus, an analysis of a simple quantitative model led Boughton *et al*. (2007b`) to conclude that an annual adult abundance of 4,150 fish were necessary for an independent population to be considered viable. But it was unclear, due to questions of exchange patterns, whether the criteria should be applied to:

- anadromous fish in a particular watershed, or
- the sum of anadromous fish across several watersheds, or
- the sum of anadromous and freshwater-resident fish in a particular watershed, or
- the sum of anadromous and freshwater-resident fish across several watersheds

The answer has implications for the scope and scale of recovery efforts. The answer depends on the level of exchange of fish across separate coastal watersheds, and on the level of exchange between the anadromous and resident forms of the species within a particular watershed—termed 'life history crossovers". A life history crossover is a freshwater parent that has anadromous fish among its progeny, and/or vice versa. Questions about inter-watershed exchanges and life history crossovers, and the implications for viability criteria, are key issues addressed in this section.

13.3.9 Partial Migration and Life History Crossovers

Partial migration is the phenomenon in which a population consists of both migratory and resident individuals (Jonsson and Jonsson, 1993), implying the regular or at least occasional occurrence of life history crossovers. A diversity of crossover patterns have been observed in the small number of studies conducted on *O. mykiss* to date. Zimmerman and Reeves (2000) observed no crossovers in resident and anadromous *O. mykiss* of the Deschutes River in Oregon, suggesting two demographically distinct (independent) populations. For one natural and eight hatchery populations in California, Donohoe *et al.* (2008) found that anadromous females sometimes produced resident progeny, but resident females did not produce anadromous progeny, suggesting a one-way flow of crossovers away from the anadromous form.

The Babine River *O. mykiss* in British Columbia apparently exhibit modest levels of crossover (*c.* 9%) in both directions (Zimmerman and Reeves, 2000), suggesting a single population that is partially subdivided, whereas J. R. Ruzycki (personal communication in Donohoe *et al.* 2008, p. 1072) reports a high level of bidirectional crossover in various tributaries of the Grande Ronde River in Oregon (0% to 33% of anadromous adults were progeny of resident females, and 44% of resident adults were progeny of anadromous females), indicating a fully integrated population in which the two life history forms functionally coexist.

[3] Over the longer term, a permanent change in population dynamics *would* be expected to trickle out to other independent populations, due to occasional exchanges of individuals. Occasional exchanges are expected to drive important processes such as gene exchange and recolonization of stream systems following a drought.

This continuum has significant implications for viability criteria. Are the populations in South-Central California fully integrated, or does each form more or less breed true, implying demographically independent populations that share stream systems but play no role in supporting one another, and perhaps even compete? Boughton *et al.* (2007b) made recommendations that embodied these two possibilities (actually two endpoints of a continuum). In one scenario, one should specify criteria that would secure the ocean-going fish if they turn out to comprise a demographically independent population. Under the other scenario, one should specify criteria that secure the ocean-going fish if they turn out to depend on the resident form with which they coexist. However, it is possible that resolution of this uncertainty would eliminate some of the need for hedging and thus lead to a more efficient and effective recovery plan. Resolution would involve two fundamental questions:

Question 1: What is the mechanism for, and frequency of, life history crossovers in South-Central California?

Question 2: How does crossover affect the persistence of the anadromous form?

Discussion: Answering the first question will take an extended research effort. Currently, Devon Pearse and S. Sogard (NOAA Fisheries) and M. Mangel (UC Santa Cruz) are leading a research effort to better understand life history crossovers in California steelhead; Mangel and Satterthwaite (2008) give an overview of the framework being used. The hypothesis being examined is that the anadromy/residency life history crossover made by individual *O. mykiss* is cued by the environment, using a mechanism similar to what has been observed in Atlantic salmon (*Salmo salar)*, a better-studied species that also exhibits variation in the timing of the smolting process during life history. Specifically, the hypothesis is that the smolting/residency life history crossover is made by individual fish during a sensitive period some months before the actual process of smolting is observed, and that the cues for the crossover are the fish's size and growth rate during the sensitive period. This might be expected because size and growth in the freshwater habitat integrate information about the quality of that habitat, as well as about the expected survival and fecundity in the marine environment versus the freshwater environment. What is hypothesized is a physiological (and perhaps hormonal) process that processes information from the environment to produce an adaptive life history crossover (see Satterthwaite *et al.* 2012, 2010, 2009, Hayes, *et al*. 2011a, 2011b).

Though the research effort of Sogard and Mangel is important progress on the anadromy/residency life history crossover phenomenon in steelhead recovery planning, it has important limitations at this time. First, it has the status of a hypothesis and at this writing no one has actually experimentally induced life history crossovers in *O. mykiss* by manipulating size, growth rates or any other environmental factor. Second, even if the Atlantic salmon model is useful for understanding life history plasticity in *O. mykiss*, there are almost certain to be important differences and indeed surprises in the *O. mykiss* life history story. Finally, the existence of a plastic life history strategy does not preclude the possibility of important genetic constraints. For example, one might expect that even if the model is broadly correct, the specific timing of sensitive periods, and the thresholds for the size and growth cues, would probably vary quite markedly among populations of steelhead due to genetic differences. In short, the responses to environmental cues would likely have a heritable component, and this component would likely exhibit local adaptation to specific conditions. A response that is adaptive in one watershed may be selected against in another watershed, depending on environmental factors such as those discussed in the previous section.

Recommendation: It is essential for rigorous research on the mechanisms of life history plasticity in *O. mykiss* to be pursued vigorously,

for it is difficult to envision a successful recovery effort without a better understanding of the functional relationship between resident and anadromous fish. The current effort of Sogard, Mangel, and coworkers should yield useful information over time, but it focuses on two systems outside South-Central California: Soquel Creek in Santa Cruz County (a coastal redwood forest system), and the American River near Sacramento (a large Central Valley River system). One should expect local adaptation of steelhead populations in South-Central California.

Because of the likelihood of local adaptation, it would be useful and practical to address some related questions about the frequency of life history crossovers and their implications for recovery planning in the South-Central California. In particular:

- Identify environmental factors that specifically promote anadromy (discussed in the previous section). It is clear that the abundance of anadromous fish needs to be increased, and identifying relevant environmental factors would usefully inform this goal. The principal uncertainty is how much the abundance of anadromous fish needs to be increased, a separate question that depends on the frequency of life history crossovers and the mechanisms underlying them. This question can be addressed over the longer term as more is learned about the mechanism, and used to refine the viability criteria described by Boughton *et al.* (2007b).

- Estimate the frequency of life history crossovers in populations of interest, to determine whether it even occurs with any regularity. The most practical method for doing so is by analyzing otolith microchemistry of juvenile *O. mykiss* (see Donohoe *et al.* 2008), but this requires lethal sampling of juveniles. Modest lethal sampling of juveniles (as opposed to adults) may pose only a negligible increase extinction risk, due to the low reproductive value of juveniles.

- Determine how life history crossover affects the persistence of the anadromous form. This could be done using existing frameworks in population modeling, such as individually-based models or integral projection models, but would require assumptions about typical mortality and growth rates in freshwater and marine environments, as well as about frequency of life history crossovers. However, it might produce important insights. For example, persistence of anadromous runs could be strongly affected by the difference between complete lack of crossovers and a modest rate, such as 5%. However, effects would be much smaller between a 10% rate versus a 50% rate. It would be useful to more rigorously evaluate the validity and relevance of these levels of life history crossovers.

13.3.10 Rates of Dispersal Between Watersheds

Question: How common is dispersal of anadromous *O. mykiss* between watersheds, and how does it relate to population structure, especially in small coastal watersheds?

Discussion: Just as life history crossovers may knit resident and anadromous *O. mykiss* into integrated populations, frequent movement of anadromous fish through the ocean to neighboring watersheds may knit neighboring *O. mykiss* into integrated "trans-watershed" populations. If inter-watershed exchange is common, the most effective recovery strategies might be those that emphasize integration of recovery efforts across a set of linked watersheds. If inter-watershed exchange is rare,

the most effective strategies would be those that identify watersheds having stable conditions that protect small, inherently vulnerable populations.

The places where the implications of the single-watershed versus trans-watershed scenarios are most distinct are those areas along the coast where numerous small coastal watersheds occur in close proximity. In the SCCCS Recovery Planning Area, these areas include the small watersheds along Big Sur Coast BPG in Monterey and northern San Luis Obispo County, and the small watersheds within the northern portion of the San Luis Obispo Terrace BPG, in San Luis Obispo County.

Recommendation: Answering this research question will involve tracking the populations from multiple watersheds, including groupings of small, closely spaced watersheds as well as groupings involving large and small watersheds more spatially dispersed. However, it is not clear at this time what is the most practical and effective way to try to estimate exchange rates in the Recovery Planning Area. Genetic and Radio Frequency Identification (RFID) tags and ecological traps may have potential to effectively address this question, particularly in small basins where it is possible to sample a significant fraction (perhaps all) of a given cohort of adults.

13.3.11 Revision of Population Viability Targets

In the framework described by Boughton *et al.* (2007b), the key criteria for establishing population viability was that a population be demonstrated to sustain a long-term mean run size of at least 4,150 anadromous spawners per watershed per year. However, the authors noted that the criteria were chosen to be precautionary due to scientific uncertainty about key issues, and that better information might allow the criteria to be revised without increasing the risk of extinction. There were three types of information that seemed most likely to lead to useful revisions of the viability criteria:

1. The threshold run size might be able to be revised downward from 4,150 spawners per year if it was determined that year-to-year variation in run size was modest enough to be consistent with a lower threshold. The necessary information—annual estimates of run size over several decades—would come from the types of monitoring programs described below.

2. Data on the frequency of life history crossovers might justify that the 4,150 threshold could include some fraction of adult resident fish, rather than the 100% anadromous fraction currently recommended (*i.e.*, because the resident and anadromous forms are shown to comprise functionally integrated populations). The necessary information would come from successfully implementing the recommendations identified above.

3. Data on inter-basin exchanges might justify that the 4,150 threshold include spawners from neighboring watersheds (*i.e.*, because inter-watershed exchanges is sufficiently high that the fish in neighboring watersheds comprise a single, trans-watershed population). The necessary information would come from successfully implementing the recommendations identified above.

It should be noted that data for item 1 would arise over time as a byproduct of a comprehensive monitoring program, which is necessary to assess risk in any case. The priority item, however, is probably item 2, since the integration of the resident and anadromous forms is not well understood, but has profound implications for a very diverse set of management issues beyond just revision of recovery criteria.

13.4 MONITORING PROGRESS TOWARD RECOVERY GOALS

Monitoring should be conducted for each BPG, with monitoring initially focused on Core 1 populations. Monitoring involves two different but related activities: status and effectiveness monitoring. Status monitoring is intended to assess the status of a population (or a DPS) as a whole, and to assess its progress toward recovery or further decline toward extinction. It should also be designed to gather data for assessing the viability criteria described by Boughton *et al*. (2007b). Monitoring the annual run size of populations is the most important objective of status monitoring. Effectiveness monitoring is intended to assess the response of populations to specific recovery actions, and thereby develop a better understand of their effectiveness. Effectiveness monitoring will generally be more powerful if it focuses on the specific life stage affected by the recovery actions in particular habitats, and it if compares it to the same life stage in similar unaffected habitats that serve as controls.

As described by Boughton *et al.* (2007b), the general goal of recovery is to establish a diverse and geographically distributed set of populations, each of which meets viability criteria over the long term. These viability criteria are expressed in terms of mean annual runs size, persistence over time, spawner density, anadromous fraction, as well as the continued expression of life history diversity, and the spatial structure of the population. Strategies for monitoring these properties of steelhead populations over the long term are essential for assessing the attainment of recovery goals.

13.4.1 Strategy for Monitoring Steelhead in South-Central California Coast

South-Central California Coast steelhead habitats exhibit characteristics that must be considered in formulating a monitoring plan. These characteristics include differences in geology, climate and hydrology, as well as the fact that other species of anadromous salmonids are absent. The differences in the geology, climate, and hydrology are described in Adams *et al.* 2011, Boughton and Goslin (2006), and Boughton *et al*. (2006). The strategy described below considers these factors, as well as the spatial and temporal distribution of South-Central California Coast steelhead. The basic components of the South-Central California Coast steelhead monitoring strategy include:

- Reconnaissance surveys and assessments of steelhead populations
- Reconnaissance surveys and assessments of riverine and estuarine habitat conditions
- Counting stations stratified at both the BPG and population levels
- Life cycle stations (LCS) stratified at both the BPG and population levels

Presently there is no current comprehensive assessment of the condition and distribution of steelhead populations and habitats in South-Central California that use standard population and habitat assessment protocols. However, NMFS and the DFG have begun to develop a comprehensive coastal salmonid monitoring program and have identified a basic strategy, design, and methods of monitoring California coastal salmonid population (Adams *et al.* 2011).

The monitoring strategy outline here includes an, initial assessment both of the fish populations and habitat conditions. Assessments should initially focus on Core 1 populations in each BPG, and ultimately include all populations that are necessary for full recovery of the species. Stream habitat assessments should be conducted using the protocol in the California Department of Fish and Game's California Salmonid Stream Habitat Restoration Manual (Flosi *et al*. 2010).

Counting stations comprised of fixed structure utilizing technologies such as DIDSON cameras

are the most effective means of establishing abundance and trends of adult anadromous runs of steelhead and juvenile out migration. Counting stations should initially be located in Core 1 populations in each BPG.

Life cycle monitoring can be co-located with counting stations, but may also be conducted in one or more of the non-core populations which support smaller but less impacted populations. LCS monitoring efforts provide the foundation for evaluating the relationship of fish habitat use and habitat condition over time and should focus on:

- Estimation of marine and freshwater survival
- Spawning success (spawning ground distribution, redd to adult ratio)
- Juvenile rearing success (over-summering and winter growth)
- Major life history traits (anadromy/resident relationships, sex ratio, age and size structure, habitat utilization patterns, emigration age and timing, maturation patterns, run-timing, and physiological tolerances)

These LCSs could also be used in evaluating nutritional needs, predation, disease, and other environmental factors relevant to assessing the status of individual populations. Where permanent LCSs are not established, temporary stations should be deployed to maximize the development of population information in Core population watersheds.

Table 14-1 lists the preliminary sites where counting stations and LCSs should be established. LCS sites should be sited based on two criteria: their relation to the DPS and whether they are necessary to represent the full range of watershed types for each BPG.

Table 13-1. Potential South-Central California Coast Steelhead Life Cycle Monitoring Stations (alternative populations are listed in parentheses).*

Life Cycle Monitoring Station	Population	Potential Locations
1	Pajaro River (Uvas, Corralitos, Little Arthur, Llagas, Dos Picachos, Pacheco)	Highway 1 Highway 101 Bloomfield Road Redwood Retreat Road
2	Salinas River (Arroyo Seco, Nacimiento, San Antonio)	Salinas Diversion Dam Highway 101 (various crossings)
3	Carmel River	Highway 1 Rancho San Carlos Road Sleepy Hallow Crossing
4	Little Sur River	Highway 1 Old Coast Highway
5	Big Sur River	Highway 1
6	San Carpoforo Creek	Highway 1
7	Arroyo de la Cruz Creek	Highway 1
8	San Simeon Creek	Highway 1 San Simeon Creek Road
9	Santa Rosa Creek	Highway 1 Santa Creek Rosa Road
10	San Luis Obispo Creek	Avila Road Highway 101
11	Pismo Creek	Highway 101 Price Canyon Road Ormonde Road
12	Arroyo Grande Creek	Highway 1 Highway 101 Lopez Drive

* Note: Additional evaluation of other locations may identify more suitable locations than those provisionally identified here.

To the maximum extent possible, monitoring the status and trends of steelhead populations should be undertaken simultaneously with restoration efforts. Watersheds where restoration has occurred or is occurring should be considered a high priority for monitoring. Monitoring stations, whether counting or life cycle stations, should serve as a magnet for research efforts depending on fish and fish related field data.

13.4.2 Monitoring Protocols

There are various ways that status and effectiveness monitoring can be integrated, but the focus of the following discussion is on status monitoring. Below is a brief summary of potential methods to monitor run-size of steelhead (number of anadromous spawners per year per population). All these methods necessarily involve two components:

1. Observed counts for some life history stage of *O. mykiss* that contains information about run size

2. Some method for estimating the number of unobserved fish

For the first component, the observed count may actually be the run, but if it is some other life stage, there is a need to collect data to estimate a conversion factor. For example, if redds are counted, it is necessary to estimate redds per female and sex ratio to get an estimate of the full run size (Gallagher and Gallagher 2005).

The second component is necessary because simple observations can confound the true number of fish with the detection rate of the observer: A large population with poor observing conditions looks the same as a small population with excellent observing conditions. Thus, one must also estimate the number of unobserved fish, which corresponds to estimating the detection rate of the observer.

There are numerous ways to do this (Williams *et al*. 2001 provides a comprehensive technical review), but they all involve making repeated observations (often only two times) of the same group of fish. This redundancy is necessary for estimating unobserved fish. Doing so, and getting an estimate of the full population, is often far more informative than obtaining partial counts in which abundance and detection rate are confounded, because detection rates can be highly variable (Rosenberger and Dunham 2005)

13.4.2.1 Counting at Fish Ladders

Fish ladders can provide important opportunities to count upstream migrants, assuming the fish passage facilities themselves provide effective unimpeded fish passage opportunities. There are a number of technical challenges in operating fish detection and counting devises in extremely flashy systems characteristic of South-Central California (see discussion below). Additionally, this method is only relevant to watersheds that have fish ladders, and cannot quantify the portion of the run that spawns below the fish ladder. Depending on the location of the ladder and the amount and type of habitat downstream of the ladder, the spawners below the ladder can be an important component of the run.

13.4.2.2 Redd Counts

Gallagher and Gallagher (2005) have shown that salmon and steelhead runs can be estimated using redd counts. A summary of their method and is provided below:

To estimate Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, and steelhead *O. mykiss* escapement in several coastal streams in northern California a stratified index redd method was developed, based on the assumption that redd size is related to the number of redds a female builds. Redd area escapement estimates were compared with estimates from more conventional methods and releases of fish above a counting structure. Reduction of counting errors and uncertainty in redd identification, biweekly surveys

throughout the spawning period, and the use of redd areas in a stratified index sampling design produced precise, reliable, and cost-effective escapement estimates for Chinook salmon, coho salmon, and steelhead.

This method has considerable promise, but has not been systematically applied in the South-Central California setting, where stream turbidity and channel geomorphology, or repeated disturbance of redds by winter storms, may make redds difficult to detect under certain circumstances. The method has high personnel requirements, because it requires the survey reaches to be visited biweekly throughout the spawning season. On the other hand, it is simple, requires only modest training in field personnel, and has modest costs other than the hiring of personnel.

13.4.2.3 Monitoring runs using the DIDSON Acoustic Camera

Dual-frequency identification sonar (DIDSON) is an off-the-shelf device that uses high frequency sound waves to produce near video-quality images of underwater objects. It can potentially be used to identify and count all migrating steelhead at some survey point in a stream system, for the entire spawning season. Its advantages are similar to those of using a weir to make counts, but has two additional advantages that are key: 1) There is no need for a weir or other device that impedes flow, and so fouling, destruction by high-flow events, etc., are not a major constraint; and 2) it can see through turbid waters (unlike a regular video camera). These two traits appear well suited to the flashy, turbid conditions typical of South-Central California streams.

DIDSON has been successfully used to estimate adult salmon escapement in high-abundance rivers in Alaska, Idaho, and British Columbia. In principle it should be suitable for low-abundance creeks, such as those in South-Central California. NOAA's' Southwest Fisheries Science Center have evaluated field methods for using the device to monitor steelhead runs in South-Central California streams (Pipal *et al.* 2010).

The principal disadvantages are: (1) the cost of the device; (2) deployment constraints for getting good images; and the risk of "flashy flows" damaging or destroying the installation. These constraints have to do with maintaining a good "insonified region" of the channel being monitored for migrants. Some channel shapes are better than others, and there also need to be a strategies for maintaining a completely insonified cross section during the advance and retreat of high flow events. In addition, there is a need to learn how to interpret poor images when they occur. However, the method has the potential to solve some of the intractable problems of monitoring steelhead in South-Central California, including counting very small numbers of migrants in very turbid waters during and after very flashy high-flow events.

13.4.2.4 Tagging Juveniles and Monitoring Migrants (T-JAMM design)

Steelhead runs can potentially be estimated by tagging juveniles with Radio Frequency Identification (RFID) tags during their freshwater phase, and subsequently monitoring migrants using in-stream tag readers.

The tagging phase use standard block-netting and electro-fishing techniques during the summer low-flow season. Depletion-sampling can be used to estimate juvenile abundances. However, Rosenberger and Dunham (2005) found that capture-recapture methods gave more robust estimates than depletion sampling, and Temple and Pearsons (2006) showed that the customary 24-hour period in capture-recapture sessions can be shortened to one or two hours, which simplifies logistics so that capture-recapture sampling can have a time-efficiency similar to that of depletion sampling.

The monitoring phase is accomplished using instream tag readers such as those described by

Bond, *et al.* (2007), Zydlewski *et al.* (2006, 2001), Ibbotson *et al.* (2004). These must be deployed for the duration of the migration season (both outgoing and incoming) each year.

The design has promise for monitoring runs of steelhead for which many other methods are problematic. In unpublished simulations, Boughton has found that the precision of run size estimates is primarily controlled by the number of tagged spawners that ultimately return and get detected. The number required is modest: around 30 to 90 tagged spawners are necessary to obtain 50% confidence intervals that stay below one-third of the estimated of run size. However, with marine survival typically falling between 0.3% and 3%, the required tagging effort would usually be between 3,400 and 45,000 juvenile fish tagged per generation per population. Other considerations in using implanted tags are the mortality/fitness risks and the permitting requirements to allow some level of take of the species. The tagging effort could perhaps be spread across a set of populations if one were willing to assume uniform marine survival across the populations.

The estimation method is robust to imperfect detection of tagged fish by the instream tag readers, as long as there are at least two readers that independently scan for tags. Reach-sampling allows the entire run to be estimated using fish from a sample of reaches. In the simulations, the number of reaches needed for acceptable precision could be as low as 30-40 under scenarios of high marine survival, with a sampling fraction of around 2% in large watersheds, such as the Arroyo Seco watershed used in the simulations.

Under low marine survival, the necessary sampling fraction was around 10% in the simulations. A side-benefit of this method is that one would obtain very good estimates of ocean survival. This is useful because it allows the overall trajectory of steelhead runs to be decomposed into marine and freshwater components. This, in turn, will deliver greater statistical power for analyzing patterns in the freshwater component. In short, one would have greater statistical power for determining if recovery actions on the freshwater side are actually having the desired effect.

Boughton has written software to estimate run size from data produced by tagging juveniles and monitoring migrants. It is written in the R computer language, a freely-available statistical programming environment that is widely used in the scientific world. Currently the work is in manuscript form. Staff scientist (T. Williams, D. Rundio, and S. Lindley) at NOAA's Southwest Fisheries Science Center are currently tagging juveniles and monitoring migrants in a case study of Big Creek steelhead population, a member of the Big Sur Coast BPG within the SCCCS DPS.

13.4.2.5 Sampling Young-of-the-Year Otoliths (YOYO design)

This method is similar to tagging juveniles and monitoring migrants, but instead of tracking the fate of captured juveniles to estimate run size, one would collect some fraction of the juveniles, and examine their otoliths and genetic relatedness. From this, one could estimate the number of anadromous mothers (and as a byproduct, non-anadromous mothers) for each annual cohort of young-of-the year fish. This should be suitable for estimating annual run size, at least of female fish.

This method would dispense with the need to implant RFID tags in fish, and the need to maintain instream tag readers during difficult winter conditions. All field work would consist of electrofishing juveniles at randomly-sampled stream reaches each summer. However, the method would require the time and expense of otolith analysis, and it would require collecting (*i.e.* killing) some fraction of the juveniles that are electrofished during the summer field season.

This method is currently not well-developed, but it has promise as a relatively simple and

efficient way to estimate run sizes using established and familiar field methods. A potential drawback is the need to kill juveniles to get their otoliths. The key unknown at this point is how many fish would have to be sampled to get a reasonable estimate of the number of anadromous mothers.

13.5 ADAPTIVE MANAGEMENT: LEARNING FROM RECOVERY EFFORTS

Adaptive management is a systematic process that uses scientific methods for monitoring, testing, and adjusting resource management policies, practices, and decisions, based on specifically defined and measurable objectives and goals (Walters 1997, 1996). Adaptive management is predicated on the recognition that natural resource systems are variable, and that knowledge of natural resource systems is often uncertain. Further, the response of natural resources systems to restoration and management actions is complex, and frequently difficult to predict with precision. The Recovery Plan provides both overall goals in the form of viability criteria, and suite of DPS-wide watershed specific recovery actions. The viability criteria, however, are provisional, and the central recovery actions are couched in broad terms which must be given more specificity on a case-by-case basis, and ultimately assessed for their effectiveness. Hence the need to adapt resource management policies, practices and research decisions to changing circumstances, or a better understanding of natural resource systems and their responses.

The success of an adaptive management program can be enhanced by having stakeholders and scientists engage in developing a shared vision for an indefinitely long future together. The development of a guiding image helps organize an adaptive management program, align interests, and enhance cooperation in a complex process. Focusing on fundamental values, rather than on predetermined means can open up possible alternative solutions; participating in this type of framework, scientists can help construct solutions that may not be self-evident to stakeholders.

Adaptive management can be applied at two basic levels: the overall goals of the recovery effort, or the individual recovery or management actions undertaken in pursuit of overall goals. The research sections above are intended to address the first application. The following discussion is focused on the second application of the concept of adaptive management.

13.5.1 Elements of an Adaptive Management Program

There is no uniformly applicable model for an adaptive management program, and key elements must be identified and tailored to recovery action-specific, site-specific, and impact-specific issues. However, effective adaptive management programs will contain three basic components: 1) adaptive experimentation by which scientists and others with appropriate expertise, learn about ecosystem functions response to recovery or management actions; 2) social learning (through public education and outreach) by which stakeholders share in the knowledge gained about ecosystem functions, and 3) institutional structures and processes of governance by which people respond by making shared decisions regarding how the ecosystem will be managed and the natural services it provides will be allocated.

Six specific elements associated with adaptive management have been identified (Panel on Adaptive Management for Resource Stewardship 2011):

1st Element: Recovery Action Objectives are Regularly Revisited and Revised. Key recovery action objectives (and related questions) should be regularly reviewed in an iterative process to help stakeholders maintain a

focus on objectives and appropriate revisions to them. The recovery goals, objectives, and criteria in Chapter 6, Steelhead Recovery Goals, Objectives & Criteria, should provide a basic framework, and the recovery actions identified for each BPG should be a starting point for the adjustment of recovery action objectives. The mandatory five-year review process can serve as a means of conveying any needed modification to the overall recovery goals, as well as individual recovery actions.

2nd Element: Model(s) of the System Being Managed. Four types of models have been have been identified in the use of adaptive management program to test hypotheses regarding the effectiveness of recovery actions (Thomas *et al.*, 2001):

Conceptual Model: Synthesis of current scientific understanding, field observation and professional judgment concerning the species, or ecological system

Diagrammatic model: Explicitly indicates interrelationships between structural components, environmental attributes and ecological processes

Mathematical model: Quantifies relationships by applying coefficients of change, formulae of correlation/causation

Computational Model: Aids in exploring or solving the mathematical relationships by analyzing the formulae on computers.

River systems are generally too complex and unique for controlled, replicated experiments, or to be the subject of traditional scientific models. However, conceptual models based on generally recognized scientific principles can provide a useful framework for refining recovery actions and testing their effectiveness. Diagrammatic models such as the one used to characterize the parallel and serial linkages in the steelhead life cycle, can also be used *in lieu* of formal mathematical models to test hypotheses regarding the effectiveness of recovery actions. Mathematical and computational models, themselves have their limitations in the context of an adaptive management program: they are difficult to explain, and require specific assumptions that may be difficult to justify. As noted in the discussion above regarding recovery goals, viability criteria are based on a combination of a synthesis of current scientific information and a simplified model which uses data not specific to the SCCCS Recovery Planning Area. Additional quantifiable data is necessary to refine the viability population and DPS models that form the basis of the provisional recovery goals, objectives and criteria. Modification of the model could result in modification of the priorities assigned to the individual recovery actions in individual populations or BPGs.

3rd Element: A Range of Management Choices. Even when a recovery action objective is agreed upon, uncertainties about the ability of possible recovery or management actions to achieve that objective are common. The range of possible recovery or management choices should be considered at the outset. This evaluation addresses the likelihood of achieving management objectives and the extent to which each alternative will generate new information or foreclose future choices. A range of recovery actions and management measures should be considered, either through a planning process or the environmental review process prior to permitting the individual recovery action.

4th Element: Monitoring and Evaluation of Outcomes. Gathering and evaluation of data allow for the testing of alternative hypotheses, and are central to improving knowledge of ecological and other systems. Monitoring should focus on significant and measurable indicators of progress toward meeting recovery objectives. Monitoring programs and results should be designed to improve understanding of environmental systems and models, to evaluate the outcomes of recovery actions, and to provide a basis for better decision making. It is critical that "thresholds" for interpreting the monitoring results are identified during the

planning of a monitoring program. This element of adaptive management will require a design based upon scientific knowledge and principles. Practical questions to be addressed include what indicators to monitor, and when and where to monitor. Guidance on a number of these issues is provided in the sections above regarding research and monitoring.

5th Element: A Mechanism for Incorporating Learning Into Future Decisions. This element recognizes the need for means to disseminate information to a wide variety of stake-holders, and a decision process for adjusting various management measures in view of the monitoring findings. Periodic evaluations of the proposed recovery action, the monitoring data and other related information, and decision-making should be an iterative process in which management objectives are regularly revisited and revised accordingly. Public outreach, including Web-based programs, should be actively pursued. Additionally, the mandatory five-year review process can serve as a means of conveying any needed modification to the Recovery Plan, and well as individual recovery actions.

6th Element: A Collaborative Structure for Stakeholder Participation and Learning. This element includes information dissemination to a variety of stakeholders, as well as a proactive program focused on soliciting decision-related inputs from a variety of stakeholder groups. Inevitably, some of the onus for adaptive management goes beyond managers, decision makers, and scientists, and rests upon interest groups and even the general public. NMFS has provided a general framework by which a shared vision can be further developed and pursued for restoring a set of watersheds supporting a network of viable steelhead populations, and providing sustainable ecological services to the human communities of South-Central California (Boughton, 2010a, Tallis *et al*. 2010, Levin *et al*., 2009, Ruckelshaus *et al*. 2008). Such a vision also provides opportunities for the protection and restoration of other native freshwater and riparian species which form an integral part of the ecosystems upon which steelhead depend.

14. Implementation by NMFS

"If anthropogenic changes can be shaped to produce disturbance regimes that more closely mimic (in both space and time) those under which the species evolved, Pacific salmon should be well equipped to deal with future challenges, just as they have throughout their evolutionary history."

Dr. Robin R. Waples, NOAA Fisheries, Research Fish Biologist

14.1 INTEGRATION OF RECOVERY INTO NMFS ACTIONS

NMFS must formally incorporate the Recovery Plans within its daily tasks and decision-making, including the actions identified in the DPS-wide Recovery Action narratives and the Recovery Action summaries for each BPG. All of NMFS' missions can be accomplished with due consideration to the needs of listed salmon and steelhead. If NMFS is to promote species and ecosystem conservation (and meet its obligations under section 7(a)(1) of the ESA), then means of incorporating recovery goals and actions must be incorporated into all of the programs and actions we administer and implement. This includes, for example, listing reviews and critical habitat designations under ESA section 4, ESA consultations under section 7, and permit actions under ESA section 10.

Implementation of the Recovery Plan by NMFS will take many forms and is generally and specifically described in the NMFS Protected Resources Division (PRD) Strategic Plan. The Interim Recovery Planning Guidance (National Marine Fisheries Service 2010a) also outlines how NMFS shall cooperate with other agencies regarding plan implementation. These documents, in addition to the ESA, shall be used by NMFS to set the framework and environment for plan implementation. The PRD Strategic Plan asserts that species conservation (in implementing Recovery Plans) by NMFS will be more strategic and proactive, rather than reactive. To maximize existing resources with workload issues and limited budgets, the PRD Strategic Plan champions organizational changes and shifts in workload priorities to focus efforts towards "those activities or areas that have biologically-significant beneficial or adverse impacts on species and ecosystem recovery" (National Marine Fisheries Service 2006a). The resultant shift will reduce NMFS engagement on those activities or projects not significant to species and ecosystem recovery.

NMFS actions to promote and implement recovery planning shall include:

- Formalizing recovery planning goals on a program-wide basis to prioritize work load allocation and decision-making (including developing mechanisms to assure the effective and timely implementation of the Recovery Plan);
- Conducting an aggressive outreach and education program aimed at all stakeholders, including federal, tribal, state, local, non–governmental organizations, landowners, and interested individuals;

- Facilitating a consistent framework for research, monitoring, and adaptive management that can directly inform recovery objectives and goals;
- Participating in the land use and water planning process at the federal, state, and local level to ensure that the provisions of the steelhead Recovery Plan are reflected in the full range of decision making processes;
- Establishing an implementation tracking system that is adaptive and pertinent to annual reporting for the Government Performance and Results Act, Bi-Annual Recovery Reports to Congress and 5-Year Reviews of each species listing status.

14.1.1 Work with Constituents and Partners

Successful implementation of Recovery Plans will require the efforts and resources of many entities, from federal agencies to the individual contributions of members of the public. NMFS commits to working cooperatively with other individuals and agencies on implementation of recovery actions and to encourage other federal agencies to implement the actions for which they have responsibility or authority. The benefits of a successful plan to the species and the currently regulated communities are immense, but the costs can be counted in time, money, and changed behaviors. NMFS is committed to using Recovery Plans as the guiding mechanism for its daily endeavors and can directly implement some of the actions called for in the plans. However, our primary role in plan implementation will be to promote the recovery strategy and provide the needed technical information and expertise to other entities implementing the part of the plan or contemplating actions that may impact the species' chances of recovery.

NMFS is engaged in outreach to various constituencies where we provide technical assistance regarding listed salmonids, their habitat needs, and various life history requirements. Developing partnerships through providing technical assistance will be critical for recovery. Our outreach efforts will need to increase both towards those constituencies with which we already engage and to expanded sets of constituencies including communities, Non-Governmental Organizations (NGOs), and Federal and State legislative representatives.

To focus efforts in areas critical for recovery, NMFS shall:

- Develop outreach and educational materials to increase public awareness and understanding of the multiple societal benefits that can be gained from steelhead recovery in South-Central California watersheds;
- Inform federal, state, and local governmental agencies of the provisions of the South-Central California Coast Steelhead Recovery Plan, and how these respective agencies' activities or planning and regulatory efforts may assist the implementation of the Recovery Plan;
- Advise watershed groups and other non-governmental organizations about the Recovery Plan, and the role of on-going watershed conservation efforts in implementing recovery actions and achieving steelhead recovery within their respective watersheds;
- Facilitate and participate in public forums designed to provide interested parties with an opportunity to directly share experiences and ideas, and learn about the methods and means of implementing steelhead recovery actions;
- Provide technical support and assistance to partners engaged in implementing steelhead recovery actions identified in the South-Central California Coast Steelhead Recovery Plan, including research and monitoring;
- Work with Federal and State agencies to coordinate and develop programmatic

permits for incidental take authorization for actions that contribute to the recovery of South-Central California Coast steelhead and their habitats;

- Work to assure adequate funding and staff support for full compliance with the legal requirements of land use, water, and natural resource protection laws, codes, regulations and ordinances across the SCCCS DPS; and
- Support the development of information networks that allow collaborators to disseminate information to a broad array of interested and affected parties about steelhead recovery efforts;
- Work with EPA Region 9 and other partners to support the amendment of the Federal Insecticide and Rodenticide Act (FIFRA) to require registrants to collect information relevant to impacts to ESA-listed salmonid species; support the implementation of best management practices (BMPs) that effectively remove pesticides from runoff;
- Work with California Regional Water Quality Control Boards to promulgate methods to detect and manage impacts from pesticides and other contaminants of especial concern (CECs) identified under 40 C.F.R. Part 136.

14.1.2 Funding Implementation of Recovery Plans

As a means of providing funding to the States, Congress established the Pacific Coastal Salmon Recovery Fund (PCSRF) to contribute to the restoration and conservation of Pacific salmon and steelhead populations and their habitats. The states of Washington, Oregon, California, Nevada, Idaho, and Alaska, and the Pacific Coastal and Columbia River tribes receive PCSRF appropriations from NMFS each year. The fund supplements existing state, tribal, and local programs to foster development of Federal-state-tribal-local partnerships in salmon and steelhead recovery and conservation. NMFS has established memoranda of understanding (MOU) with the states of Washington, Oregon, California, Idaho, and Alaska, and with three tribal commissions on behalf of 28 Indian tribes. The MOUs establish criteria and processes for funding priority PCSRF projects.

For as long as these funds are available to the State of California, NMFS intends on working with the State to ensure the South-Central California Coast steelhead recovery strategy and priorities are included in the considerations of funding for projects. NMFS also intends on using PCSRF reports as a mechanism to highlight those areas and actions where PCSRF funds have been used to implement needed recovery actions that might not otherwise occur in the absence of PCSRF funds.

NMFS has also identified other potential funding sources to support the implementation of recovery actions identified in the South-Central California Coast Steelhead Recovery Plan (for a list of additional funding sources, see Appendix E, Habitat Restoration Cost References for Steelhead Recovery Planning).

14.2 ONGOING REGULATORY PRACTICES

The ESA provides NMFS with various tools for first protecting and then recovering listed species. The ESA focuses on first identifying species and ecosystems in danger of immediate or foreseeable extinction or destruction and protecting them as their condition warrants. Then, the ESA focuses on the prevention of further declines in their condition through the consultation provisions of section 7(a)(2), habitat protection and enhancement provisions of sections 4 and 5, take prohibitions through sections 4(d) and 9, cooperation with the State(s) in which these species are found (section 6) and needed research and enhancement as well as conservation of species taken by non-federal actions through section 10. Ultimately, the ESA focuses on the conservation (commonly equated with the term recovery) of these species and

ecosystems through the recovery planning provisions of section 4, cooperation with States in section 6, and direction to all federal agencies to conserve species in section 7(a)(1). Clean Water Action Section 404 is an important tool for regulating the discharge of material or the additional of fill material to the rivers, streams, and estuaries of California, and is one of the principle means by which consultations under section 7(a)(2) can be initiated.

In the case of listed salmon and steelhead in California, NMFS has already used the listing and designation of critical habitat provisions to protect the current populations of these species. For the past two decades, NMFS has also worked closely with federal agencies and private landowners pursuant to sections 7(a)(2) and 10(a)(1) of the ESA to avoid and minimize additional harm to these species during the course of land and water-use activities. Significant benefits have already accrued to these listed species from changes in land and water-use practices. Unfortunately, in many areas, salmon and steelhead populations continue to decline. The development and implementation of Recovery Plans has a greater scope and objective than the project-by-project focus of most section 7 and 10 efforts, however. NMFS intends to use this broader perspective to effect more significant and focused beneficial change for salmon and steelhead. In addition, NMFS intends to implement every action within this Recovery Plan for which it has authority.

The following sections describe the methods NMFS intends to use when implementing various sections of the ESA. These methods are intended to institutionalize the Recovery Plans in the daily efforts and decision-making at NMFS in the Southwest Region. Of necessity, some of these methods address the urgent issues of staffing and workload that NMFS faces. As a result, our commitment to implementing Recovery Plans extends to the ways in which we prioritize the many requests for consultations and permits we receive.

14.2.1 ESA Section 4

Section 4 provides the mechanisms to list new species as threatened or endangered, designate critical habitat, develop protective regulations for threatened species, and to develop Recovery Plans. The currently designated critical habitat includes only a portion of the habitat which may be necessary for recovery of the DPS. NMFS intends on using our recovery strategy, recovery criteria and recommended recovery actions to review the SCCCS DPS critical habitat designation. A review of the current critical habitat designations may result in modifications of the current critical habitat designations, including the addition of unoccupied habitat which exhibit Primary Constituent Elements (PCEs).

14.2.2 ESA Section 5

Section 5 is a program that applies to land acquisition with respect to the National Forest System. The Los Padres National Forest is present within the range of South-Central California Coast steelhead. As funds become available, NMFS will work with the U.S. Forest Service to acquire important habitat areas for the purpose of protecting habitat features and functions needed to support the expression of diversity and spatial structure in the species.

14.2.3 ESA Section 7

14.2.3.1 Section 7(a) (1)

Section 7(a)(1) provides that all Federal agencies shall "…in consultation with and with the assistance of the Secretary, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species…". Section 7(a)(1) provides that Federal agencies give the conservation of threatened species a high priority.

To prompt Federal agencies to develop conservation programs to fulfill their Federal obligations, NMFS shall:

- Prepare, and send, after Recovery Plan approval, a letter to all other appropriate Federal agencies outlining section 7(a)(1) obligations and meet with these agencies to discuss listed steelhead conservation and recovery priorities;
- Incorporate recovery actions in formal consultations as Conservation Recommendations;
- Encourage meaningful and focused mitigation, in alignment with recovery goals for restoration and threats abatement, for all actions that incidentally take steelhead or affect their habitat;
- Encourage Federal partners to include recovery actions in project proposals; and
- Incorporate conservation actions, including BMPs, as appropriate, into the actions that NMFS authorizes, funds, or carries out.

14.2.3.2 Section 7(a) (2)

The purpose of section 7(a)(2) is to "insure that any action authorized, funded, or carried out by [a Federal agency] is not likely to jeopardize the continued existence of any [listed species] or result in the destruction or adverse modification of [a listed species' critical habitat]." Federal agencies request interagency consultation with NMFS when they determine an action may affect a listed species or its critical habitat. NMFS then conducts an analysis of potential effects of the action. In the process of consultation, NMFS currently expends considerable effort to assist agencies in avoiding and minimizing the potential effects of proposed actions, and to ensure agency actions do not jeopardize a species or destroy or degrade habitat. Whether the action has a negative effect on the likelihood of the species recovering is considered as part of the analysis; the action may not appreciably reduce the likelihood of recovery. As a result, these consultations have helped avoid and minimize direct take and contributed to recovery of SCCCS DPS.

Because section 7(a)(2) applies only to Federal actions, its applications are limited only to those areas and actions with federal ownership, oversight, or funding. In the SCCCS DPS, land ownership varies across the watersheds from areas with significant levels of public ownership to areas almost entirely privately owned. Most of the land use practices on private ownership do not trigger interagency consultation.

Currently, NMFS expends most of its staff time and resources on conducting section 7 consultations. Implementation of the Recovery Plan will require improvements to the process and application of section 7(a)(2) consultation requirements across the SCCCS DPS.

In order to devote more resources towards recovery action implementation and to ensure section 7(a)(2) consultations are effective, NMFS will utilize its authorities to:

- Use recovery criteria, objectives, and ongoing monitoring efforts as a reference point to determine effects of proposed actions on the likelihood of species' recovery;
- Utilize information on threats to species recovery and needed actions to address such threats when evaluating the impacts of proposed Federal actions on South-Central California Coast steelhead;
- Place high priority on consultations for actions that implement the recovery strategy or specific recovery actions;
- Develop and maintain databases to track the amount of incidental take authorized and effectiveness of conservation and mitigation measures;

- Incorporate recovery actions in formal consultations as Reasonable and Prudent Measures, Reasonable and Prudent Alternatives, and Conservation Recommendations as appropriate;
- Focus staff priorities towards section 7 and 9 compliance in watersheds identified as core populations for the purpose of recovery of the SCCCS DPS;
- Streamline consultations for those actions with little or no effect on recovery areas or priorities. Develop streamlined programmatic approaches for those actions that do not pose a threat to the survival and recovery of the species; and
- Apply the VSP framework and recovery priorities to evaluate population and area importance in jeopardy and adverse modification analyses.

Within this framework NMFS will utilize its authorities to encourage:

- Federal Emergency Management Agency (FEMA) to fund upgrades for flood-damaged facilities to meet the requirements of the ESA and facilitate recovery;
- Environmental Protection Agency (EPA) to prioritize actions on pesticides known to be toxic to fish and/or are likely to be found in fish habitat; and to take protective actions, such as restrictions on pesticide use near water;
- Development of section 7 Conservation Recommendations to help prioritize Federal funding towards recovery actions (NFMS, USFWS, NRCS, EPA, *etc.*) during formal consultations;
- All Federal agencies that designate a non-Federal representative to conduct informal consultation or prepare a biological assessment to ensure the associated documentation comports to 50 CFR 402.14(c) prior to initiating consultations with NMFS; Compliance with these requirements is expected to increase consultation effectiveness and timeliness;
- All Federal agencies, or their designated representatives, to field review projects and actions upon project completion to determine whether or not the projects were implemented as planned and approved. Encourage all Federal agencies, or their designated representatives to report the initial findings of field review to NMFS; and
- Federal agencies to coordinate and develop programmatic incidental take authorization for activities that contribute to the recovery of South-Central California Coast steelhead to streamline their permitting processes

14.2.4 ESA Section 9

Section 9 prohibits any person from harming members of listed species including direct forms of harm such as killing an individual, or indirect forms such as destruction of habitat where individuals rear or spawn. The Recovery Plan will assist NMFS' Office of Law Enforcement (OLE) personnel by targeting focus watersheds essential for species recovery. NMFS PRD staff will work closely with NMFS' OLE regarding the identification of threats and other activities believed to place steelhead at high risk of take.

Towards this end, NMFS will:

- Conduct outreach and provide the NMFS' OLE a summary of the recovery priorities and threats;
- Prioritize those actions and areas deemed of greatest threat or importance for focused efforts to halt illegal take of listed species
- Periodically review existing protocols establishing responsibilities and priorities between PRD and Enforcement to ensure activities by NMFS staff, when supporting NMFS' OLE are focused on the highest recovery priorities; and

- When take has occurred in a primary focus area, NMFS PRD will work with NMFS' OLE, to the extent feasible, with the development of a take statement.

14.2.5 ESA Section 10

Section 10(a)(1)(A) provides permits for the authorization of take of listed species for scientific research purposes, or to enhance the propagation or survival of listed species. Typically NMFS has authorized conservation hatcheries and research activities under section 10(a)(1)(A). Section 10(a)(1)(B) provides permits for otherwise lawful activities that incidentally take listed species. Habitat conservation plans minimizing and mitigating the incidental take of listed species from non-federal activities are prepared under section 10(a)(1)(B). Currently, both processes take a long time to implement and Recovery Plans have not been available to guide priorities for permit issuance. To improve the section 10 authorization process, NMFS will utilize its authorities in the following ways:

14.2.5.1 Section 10(a) (1) (A) Research Permits

In order to assure that the best available science is developed and used to recover the SCCCS DPS NMFS will:

- Prioritize permit applications that address identified research, monitoring, and/or enhancement activities, including any conservation hatchery operations, in the South-Central California Coast Steelhead Recovery Plan;
- Evaluate all proposed research and/or enhancement activities within the framework of identified threats, recovery strategy, and recovery actions identified in the Recovery Plan;
- Develop a streamlined process for permitting priority research activities to facilitate the implementation of the research program identified in the Recovery Plan; and
- Support and maintain the national research and enhancement database to track the amount of take authorized and the effectiveness of conservation and mitigation measures identified in the Recovery Plan.

14.2.5.2 Section 10(a) (1) (B) Habitat Conservation Plans

To ensure that all of the mechanisms available to achieve the goals, objectives and criteria of the South-Central California Coast Steelhead Recovery Plan, NMFS will:

- Place the highest priority on cooperation and assistance to landowners proposing activities or programs designed to achieve recovery objectives; and
- Prioritize those areas and actions where threats abatement has the potential to provide the most significant contribution to species recovery based on the threats assessment developed and updated as part of the Recovery Plan.

APPENDIX A

Glossary and Abbreviations

Acclimation
Gradual physiological adjustment in response to relatively long-term environmental changes.

Acidification
Ocean acidification is the process by which CO_2 is dissolved in seawater resulting in an increase in hydrogen ion (H+) concentration, and a corresponding decrease in the ocean's pH.

Acid Rain
Precipitation which contains sulfate aerosols consisting of sulfuric acid, derived from industrial and other emissions.

Adaptation
The evolutionary process, whereby populations become better suited to deal with their physical and biological environments, and therefore to survive and reproduce. It is driven by a host of factors including population diversity (genetic, phenotypic, physiological, and behavioral), inter and intra-specific competition, natural selection, and genetic processes.

Adaptive Trait
Any specific physical, physiological, or behavioral trait of an organism that promotes the likelihood of an organism's survival and reproduction in a particular environment.

Adfluvial Population
A population of fish which migrates between a lake and tributary streams tributary to the lake.

Adiabatic
Insulated from the surroundings, unable to gain or lose heat from the environment.

Adipose fin
Small fin composed of fatty tissue and located on the top-side of a fish between the dorsal and caudal fin.

Adjuvant
An agent that modifies the effect of other agents, such as a pesticide. They are sometimes included in pesticides to enhance the effectiveness of the active agent.

Age Class
Individuals in a population of the same age. In Pacific salmonids, an individual of less than one year is referred to a 0+ age class; a fish older than one, but less than two years, is termed a 1+ age class fish, etc.

Albedo
The fraction of incoming solar radiation that is reflected back to space without being absorbed.

Alevin
Newly hatched salmon or trout with a visible yolk sac, usually still maturing while still in the redd.

Allele
One of two or more forms of a gene. Sometimes, different alleles can result in different physical or physiological traits. Other times, different alleles will have the same result in the expression of a gene.

Allele Frequency
The relative proportion of all copies of a particular gene variant (allele) among the chromosomes carried by an individual of a population. In population genetics, allele frequencies are used to depict the amount of genetic diversity at the individual, population, and species level.

Allochthonous
Derived from outside a system such as leaves or insects that may fall into a stream.

Alluvial
Deposited by running water.

Alluvium
Material deposited by running water, including the sediments laid down in riverbeds, floodplains, lakes and estuaries.

Anadromous
A life history cycle that involves reproducing in freshwater, maturing in marine waters, and returning to freshwater to reproduce.

Anadromous Fraction
The proportion of a heterogeneous *O. mykiss* population that exhibits an anadromous life history, as opposed to the freshwater-resident life history.

Anadromous Waters
Water bodies typically accessible to fish migrating from the ocean, including estuaries, rivers, and lakes.

Anaerobic
Living, growing, or occurring in an environment with no free oxygen.

Anal fin
Fin located near the rear, and on the bottom side of a fish; used for stability when swimming.

Annulus
An annual mark formed on the hard parts of fishes (e.g., scales, bones, otoliths), corresponding to a period of growth.

Autecology
Ecological study of a single organism or a single species.

Autochthonous
Derived from within a system, such as organic matter in a stream resulting from photosynthesis by aquatic plans.

Autotrophic
Making food by photosynthesis or requiring only inorganic chemical for metabolic synthesis.

Baseflow
The portion of a stream discharge derived from natural storage sources such as groundwater, lakes, or groundwater basins that create local surface runoff; the sustained discharge that does not result from direct runoff or from stream regulation, water diversion, or other human activities.

Baseline
A set of reference data sets or analyses use for comparative purposes; it can be based on a reference year or location, or a reference set of standard conditions.

Bayesian
A formal statistical approach in which expert knowledge or beliefs are analyzed together with data. Bayesian methods make explicit use of probability for quantifying uncertainty, and are used in decision making.

Bedform roughness
The measure of the irregularity of streambed materials that contributes to the resistance to stream flows. Commonly represented by Mannings roughness coefficient.

Bed-load Sediment
The part of a stream or river's total sediment load moved along the bottom by running waters.

Benthic
A habitat or organism found on the stream, lake or ocean bottom.

Biological Diversity
The range of characteristics within an ecosystem or taxonomic group, including genetic, phenotypic and physiological variability of individuals, and life history strategies, age structure and fecundity of populations.

Bootstrap
A statistical methodology use to quantify the uncertainty associated with estimates obtained from a model. The bootstrap is often based on Monte Carlo resampling of residuals from the initial model fit.

Brackish Water
Water that contains high concentrations of salts than fresh water, but not as much as seawater. It may result from mixing of seawater with fresh water, as in estuaries, or it may occur in brackish fossil aquifers. Technically, brackish water contains between 0.5 and 30 grams of salt per liter—more often expressed as 0.5 to 30 parts per thousand (ppt or ‰). Thus, *brackish* covers a range of salinity regimes and is not a precisely defined condition. By comparison, average, seawater in the world's oceans has a salinity of about 35 ppt.

Braided Stream
Stream that forms an interlacing network of branching and recombining channels separated by branch island or channel bars.

Broodstock
Sexually mature individuals used within a hatchery or other controlled environment for breeding purposes.

Carnivore
An organism or species that derives its energy and nutrient requirements from a diet consisting mainly or exclusively of animal tissue, whether through predation or scavenging. Animals that depend solely on animal flesh for their nutrient requirements are considered obligate carnivores while those that also consume non-animal food are considered facultative carnivores.

Carrying Capacity
The maximum population of a species that an area or specific ecosystem can support indefinitely without deterioration of the character and quality of the resources. It can also refer to the maximum level of recreational use, in term of numbers of people and type of activity, which can be accommodated before the ecological value of the area declines.

Catadromous
A life history cycle that involves reproducing in saltwater, maturing in freshwater, and returning to saltwater to reproduce.

Caudal fin
Tail fin, usually with distinct rays; used principally for propulsion and turning.

Climate
The average prevailing conditions in the atmosphere (air temperature, wind speed and direction, humidity, precipitation, etc.) based upon an extended series of years.

Coded-wire Tag
Coded-wire tags are small pieces of stainless steel wire that are injected into the snouts of juvenile salmon and steelhead. Each tag is etched with a binary code that identifies its time and place of release.

Coefficient of Variation (CV)
The standard error of a statistic, divided by its point estimate. The CV gives an idea of the precision of an estimate, independent of its magnitude.

Colluvium
Lose deposits of soil and rock moved by gravity; on or below step slopes or cliffs it is referred to as talus.

Competition
Interaction of individual organisms that occupy or share some part of an ecological niche such that both depend upon the same food source, shelter, or some other resource in the same community; competition may be between individuals of the same or different species.

Cohort
A group of fish generated during the same spawning season, and is part of the same age class.

Confidence Interval (CI)
The probability, based on statistics, that a number will be between and upper and lower bound.

Conspecific
Two or more individuals, populations, or other higher order taxonomic grouping such as a sub-species, are said to be conspecific when they belong to the same species.

Continental Shelf
The underwater shelf of the continent, extending seaward from the shore, with a moderate inclination, to the edge of the continental slope where the inclination increases sharply; water depth varies from 0 to 200 meters.

Demersal
Living in close association with the bottom of a stream or lake and generally dependent upon it.

Demographic
Properties of a population such as rate of growth, age structure, sex ratio, number of reproductive individuals, etc.

Density Dependence
In population ecology density-dependence is any population characteristic that varies with the degree of the density of the population.

Density Independence
External factors that influence all individuals of a population regardless of population density such as climate.

Dimorphism
Existence within a species of two distinct forms according to color, sex, size, organic structure, etc.

Distinct Population Segment
The smallest division of a taxonomic species that can be protected under the U.S. Endangered Species Act.

Dorsal fin
Located on the top side, generally mid-way along the body, and usually with distinct rays; provides stability when swimming.

Ecological niche
The position a species or population in its ecosystem. The ecological niche describes how an organism or population responds to the distribution of resources and competitors (*e.g.*, by growing when resources are abundant, and when predators, parasites and pathogens are scarce) and how it in turn alters those same factors (*e.g.*, limiting access to resources by other organisms, acting as a food source for predators and a consumer of prey).

Ecosystem

A biological environment consisting of all the organisms living and interacting in a particular area, as well as all the nonliving, physical components of the environment with which the organisms interact, such as air, soil, water and sunlight.

Ecosystem Functions
Intrinsic ecosystem characteristics related to the set of conditions and processes whereby an ecosystem maintains its integrity. Ecosystem functions include such processes as decomposition, production of biomass, nutrient cycling, and fluxes of nutrients and energy.

Ecosystem Services
The benefits that people obtain from functioning ecosystems; they include provisioning services such as food, timber, fiber, fuel and energy, and freshwater; regulating services such as air and water quality, equable climate, control of diseases, pests, and sediment supplies (e.g., beaches, natural building materials such as wood); supporting services such as soil formation, photosynthesis, nutrient cycle; and cultural services such as fulfilling spiritual, religious, and aesthetic needs.

Effective Population Size (N_e)
The number of individuals that contribute offspring to the next generation; generally smaller than the absolute population size (N); a basic parameter in many models in population genetics.

El Niño /La Niña Southern Oscillation
A weather pattern that occurs across the tropical Pacific Ocean roughly every five to seven years. It is characterized by variations in the surface temperature of the tropical eastern Pacific Ocean—warming associated with El Niño and cooling with La Niña. The two variations are coupled: the warm oceanic phase, El Niño, accompanies high air surface pressure in the western Pacific, while the cold phase, La Niña, accompanies low air surface pressure in the western Pacific. ENSO causes extreme weather (such as floods and droughts) in many regions of the world, including the west coast of the United States.

Embeddedness
The degree to which large particles (e.g., boulders, ruble, gravel) are surrounded or covered by fine sediment, usually measured in classes according to percent of coverage.

Emigration
Movement of individuals out of a population. With Pacific anadromous salmonids, emigration refers to the movement of juveniles (and also adults) from freshwater to a brackish or marine environment.

Endemic
Species or populations occurring in restricted geographic areas due to the presence of a unique suite of environmental and biological conditions that limit the distribution of the species or population.

Ephemeral Streams
Streams that flow briefly after rainstorms.

Epigenetics
The field of study of the genetic (coding) and non-genetic (non-coding) factors acting upon cells to control selectively the expression of genes that produce development and evolution.

Epigenome
All the epigenetic modifications on the DNA genome and its associated histone proteins.

Escapement
The portion of a run of an anadromous species that is not harvested and escapes to natural or artificial spawning areas.

Essential Fish Habitat
Waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity as defined by 16U.S.C. 1802(10).

Estuary
Estuaries form a transition zone between river environments and ocean environments and are subject to both marine influences, such as tides, waves, and the influx of saline water; and riverine influences, such as flows of fresh water and sediment. The inflow of both seawater and freshwater provide high levels of nutrients in both the water column and sediment, making estuaries among the most productive natural habitats.

Eutrophication
The process by which a body of water becomes enriched in dissolved mineral nutrients (often phosphorus and nitrogen) that stimulates the growth of aquatic plants, and leads to depletion of dissolved oxygen, and the mortality of oxygen dependent organisms.

Evolutionary Significant Unit
A population (or group of populations) which exhibit two biological characteristics: (1) it is substantially reproductively isolated from other conspecific (of the same taxonomic species) population units; and (2) it represents an important component of the evolutionary legacy of the species.

Evolvability
The potential to generate heritable variation of individuals in a population that can be exploited by natural or artificial selection.

Extinction
The disappearance of a species or some other taxonomic group from a region, niche, or biota; the precise moment of extinction is generally considered to be the death of the last individual of the species (although the capacity to reproduce and recover may have been lost before that point).

Eyed Egg
A fish egg containing an embryo that has developed to the point where the eyes are visible through the egg membrane.

Facultative
The characteristic of being able to adjust to a variety of conditions or circumstances; optional or discretionary.

Fecundity
The reproductive potential or capacity of an organism or population, usually expressed as the number of eggs or progeny produced during a reproductive cycle. Fecundity usually increases with age and size up to some upper limit.

Fish Ladder
An artificial facility made of a series of steps, with flowing water and pools, to assist fish in swimming up or downstream of a fish passage barrier such as a dam or diversion.

Fitness
The degree that an individual is adapted to or is able to produce progeny in its local environment.

Fluvial
Pertaining to streams or rivers, or produced by stream action; also migrating between rivers and the ocean.

Fork- Length
Refers to the measurement of a fish from the tip of its snout to the fork in the caudal (tail) fin.

Fry
Juvenile fish that have absorbed their yolk sacs and can emerge from a redd and into deeper water to feed on their own.

Genotype
The genotype of an organism is the inherited genetic code of the individual. Not all individuals with the same genotype look or behave the same way because appearance and behavior are modified by environmental, developmental, or epigenetic factors. Similarly, not all individual that look alike necessarily have the same genotype.

Genetic Distance
A measure of the difference in allele frequencies between populations. Genetic distance can be used to compare the genetic similarity between different species, such as humans and chimpanzees. Within a species genetic distance can be used to measure the divergence between different sub-species, or populations of the same species.

Gravid
The condition of an individual female carrying ripe eggs, usually with a distended body.

Greenhouse Gas
A gas which is capable of absorbing and emitting infrared light (e.g., water vapor H_20, carbon dioxide $C0_2$, methane CH_4, nitrous oxide N_20, and ozone O_3).

Habitat
The area that is inhabited by a particular species of animal, plant or other type of organisms. It is the natural environment in which an organism lives, or the physical environment that surrounds (influences and is utilized by) a population of a species. The term microhabitat is often used to describe the small-scale physical requirements of a particular organism or population.

Herbivore
An organism that derives is principal source of nutrients and energy by consuming living plants or their parts.

Hydrologic Cycle
The continuous movement of water on, above and below the surface of the Earth, such as from river to ocean, or from the ocean to the atmosphere, by the physical processes of evaporation, condensation, precipitation, infiltration, runoff, and subsurface flow. Water takes alternative forms of liquid, vapor, and a solid (snow and ice). The hydrologic cycle also involves the exchange of heat energy, which leads to temperature changes. For instance, in the process of evaporation, water takes up energy from the surroundings and cools the environment. Conversely, in the process of condensation, water releases energy to its surroundings, warming the environment.

The water cycle figures significantly in the maintenance of life and ecosystems on Earth. By transferring water from one location to another, the water cycle purifies water, replenishes the land with freshwater, and transports minerals to different parts of the globe. It is also involved in reshaping the geological features of the Earth, through such processes as erosion and sedimentation. The water cycle exerts an influence on climate as well.

The physiological and behavioral process by which migratory fish assimilate environmental cues to aid their return to their stream of origin as adults.

Imprinting
The physiological and behavioral process by which migratory fish assimilate environmental cues to aid their return to their stream of origin as adults.

Incidental Take
The unintentional take of a listed species as a result of the conduct of an otherwise lawful activity.

Independent population
Any collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time frame are not substantially altered by exchanges of individuals with other populations. For example, if one independent population were to go extinct, it would not have a significant impact on the 100-year extinction risk experienced by other independent populations.

Indigenous Species
A species occurring naturally in a particular region, and not artificially introduced.

Intermittent Streams
Streams that flow for some portion, but not all, of the year. Such streams usually receive their waters primarily from surface runoff following storm events.

Interspecific
Interactions, such as competition or predation, between different species.

Interrupted Stream
Stream that exhibit surface and sub-surface flow along difference stream reaches contemporaneously. Such streams often flow through coarse gravels.

Intraspecific
Interactions, such as competition or predation, between individuals of a single species.

Introgression
The movement of genes from one gene pool to another as a result of hybridization between individuals from genetically distinct populations.

Iteroparous
An organism that has the potential to reproduce more than one during its life cycle. Steelhead are the only members of the Pacific anadromous salmonids (*Oncorhynchus* spp.) that do not die after initial spawning , and may return to the ocean and then return to freshwater to repeat their reproductive phase.

Kelt
A spawned out anadromous fish; it is generally emaciated and weak as a result of its spawning activity.

Latent Heat
Heat carried by water, and released when the water vapor condenses to liquid.

Lateral line
A series of sensory receptors (formed of a series of pores with hair-like structures) arrayed along the sides mid-way between top and bottom of the body; these sensory receptors detect water movement around the fish, allowing it to efficiently navigate currents, detect prey, and swim in coordination with other fish of the same species.

Life Cycle
The successive series of changes through which an organism passes, whether through asexual or sexual reproduction, including breeding, gestation, growth and maturation, and death. This cycle of phases of an individual is also referred to a life history.

Life History Crossover
In Pacific salmonids, the ability of anadromous *O. mykiss to* produce progeny which assume a freshwater reproductive life cycle, and the ability of resident *O. mykiss*, to produce progeny which assume an anadromous reproductive life cycle.

Life History Polymorphism
In Pacific salmonids, the co-occurrence of the anadromous and resident life cycle forms within a population.

Limiting Factor
Any factor that controls a process, such as organism growth or species population size, or distribution. The availability of food, predation pressure, or availability of shelter are examples of natural limiting factors. An example of an anthropogenic limiting factor is set of barriers to migration, which is necessary to complete an organism's life cycle.

Littoral Zone
The zone along the coast the forms the interface between the land and water, and often includes intertidal and near-shore waters.

Lotic
Pertaining to running water such as river or stream.

Mediterranean Climate
The climate is characterized by warm to hot, dry summers and mild to cool, wet winters. Mediterranean climate zones are associated with the five large subtropical high pressure cells of the major oceans. These high pressure cells shift toward the poles in the summer and toward equator in the winter.

Meristics
Measurements of an organism's physical characteristics such as length, scale, spine, fin-ray counts.

Metapopulation
A set of populations that is composed of multiple local populations geographically separated but connected through dispersal and periodic interbreeding. Generally individual populations within such a system have a relatively high probability of local extinction and also recolonization by other populations within the metapopulation. Metapopulations persist as a result of a balance between extinctions of subpopulations and recolonization by others.

Migrate
Travelling of long distances in search of a specific type of habitat to enable an organism to complete some phase of its life cycle; fish such as Pacific anadromous salmonids migrate between their spawning and rearing areas in freshwater habitat and the marine environment to feed and grow to maturity.

Mathematical Model
A quantitative description of anything (including processes) that cannot be directly observed, but for which relevant data can be developed, and used to simulate an approximation or estimate of the thing being modeled.

Natal Stream
A stream in which a returning adult fish was originally spawned and reared.

Natural Selection
The process by which the frequency of genetic traits in a population through differential survival and reproduction of individual bearing those traits is determined. Natural selection acts on the phenotype or the observable characteristics of an organism, but the genetic (heritable) basis of any phenotype which gives a reproductive advantage will become more common in a population (see allele frequency). Over time, this process can result in modifications in individual organisms that adapt populations for a particular ecological niche and may eventually result in the emergence of new species. It is a key mechanism of evolution.

Non-Point Pollution
Pollution from sources that cannot be defined as discrete points, such as areas of surface mining, construction, or developed agricultural or urbanized areas.

Obligate
The characteristic of being unable able to adjust to a variety of conditions or circumstances; a life history or response to particular environmental conditions without alternative means of responding.

Omnivore
An organism whose diet is broad, including both plant and animal foods; specifically an organism that feeds on more than one trophic level; omnivorous organisms are opportunistic, general feeders not specifically adapted to eat and digest either meat or plant material primarily.

Operculum
The hard bony gill cover in bony fishes

Orographic Precipitation
Precipitation induced when air masses pushed by winds are forced up the side of elevated land formations, such as large mountains. The lift of the air up the side of the mountain results in cooling, and ultimately condensation and precipitation.

Otolith
Calcareous concretions in the inner "ear" of lower vertebrates such as fish; the daily accumulation of calcareous layers can be used to determine the age of an organism, and in some cases detect the relative amount of time spent in waters with different chemical composition (*e.g.*, salt and freshwater).

Outmigration
The downstream migration of juvenile fish toward the ocean. See **Emigration.**

Oviparous
Producing eggs that develop outside the females body. Fertilization may occur either inside a female or after the eggs are released by the embryos are given no extra nutrient other than that contained in the original yolk.

Pacific Decadal Oscillation (PDO)
A pattern of climate variability that shifts phases on at least an inter-decadal time scale, usually about 20 to 30 years. The PDO is detected as warm or cool surface waters in the Pacific Ocean north of 20° N. During a "warm", or "positive", phase, a part of the eastern ocean warms, while the west Pacific becomes cool; during a "cool" or "negative" phase, the opposite pattern occurs.

Panmictic Population
A population in which all individuals are potential reproductive partners, that is, there are no restrictions of mating (*e.g.*, genetic or behavioral).

Parameterization
A technique used in constructing models by substituting an unknown feature such as process or limit, with a simplified, but informed estimate of the feature.

Parr
The rearing stage of freshwater salmonids between alevins and smolt that is distinguished by vertical bars or oval spots (parr marks) on the side of the fish.

Pectoral fin
Fin located toward the front of fish; used for precise movements.

Pelvic fin
Fin located toward the rear of the fish; used for steering and stopping.

Pelagic
Associated with the open sea or at or near the water's surface. Pelagic fish live near the surface or in the water column of coastal, ocean and lake waters, but not on the bottom of the sea or the lake. They are usually agile swimmers with streamlined bodies, capable of sustained cruising on long distance migrations. They can be contrasted with demersal fish which do live on or near the bottom, and reef fish which are associated with coral or volcanic reefs.

pH
A measure of the acidity or basicity of an aqueous solution (generally expressed as the concentration of H^+ ions). pH is normally measured in a range of 0-14. Pure water is said to be neutral, with a pH close to 7.0 at 25 ^{0}C (77 ^{0}F). Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline.

Phenotype
Any observable characteristic or trait of an organism such as its morphology (shape and size) developmental pattern, biochemical or physiological properties, and behavior. Phenotypes result from the expression of an organism's genes working in conjunction with epigenetic factors as well as the influence of environmental factors and the interactions between the two.

Phenotypic Plasticity
The ability of an individual to modify behavioral or other phenotypic characteristics to adjust to differing environmental conditions. In some Pacific salmonids such as steelhead, phenotypic plasticity refers to the ability to adopt either the anadromous or freshwater-resident life cycle, depending on environmental cues or influences.

Photic Zone
The surface layer of water where there is sufficient light for photosynthesis to occur.

Point-Source Pollution
Pollution originating from a confined, discrete source such as a pipe, ditch, oil-well, or factory.

Population
A group of interbreeding individuals that have developed a distinct gene pool and that breed in approximately the same place and time.

Population Density
The number of individuals per unit area, or linear distance.

Population Model
A quantitative description of how a population changes over time; population models can take a variety of basic forms, including age/size structured or biomass based, deterministic or stochastic, density-dependent or density-independent, spatially structured or spatially aggregated, equilibrium or nonequilibrium.

Predation
Predation describes a biological interaction in which a predator feeds on its prey. Predators may or may not kill their prey prior to feeding them, but the act of predation always results in the death of its prey and the eventual absorption of the prey's tissue through consumption. The key characteristic of predation however is the predator's direct impact on the prey population.

Primary Productivity
The production of organic compounds from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis, with chemosynthesis being much less prevalent. Almost all life on earth is directly or indirectly reliant on primary production. The organisms responsible for primary production form the base of the food chain. In terrestrial ecosystem these are mainly plants; in aquatic ecosystems, algae are primarily responsible.

Radiative Balance
The physical state of a system, such as the earth-atmosphere system, where the incoming and outgoing solar radiation is in equilibrium; greenhouse gases diminish outgoing solar radiation, thus disrupting the radiative balance**.**

R-strategists
R-strategists are species characterized by relatively early age of first reproduction, large brood size, numerous progeny, no parental care, and short generations. Populations exhibit exponential growth rate followed by sudden crashes in population size, and tend to live in unpredictable and rapidly changing environments. Pacific anadromous salmonids are an example of an r-strategist species.

Recruitment
The number of fish from a year class reaching a certain age; in fisheries management it is generally the number of fish that grow to a size subject to harvesting.

Redd
A shallow gravel depression excavated by a fish for the purpose of depositing its eggs within the stream channel.

Refugia
Habitats where individuals can avoid predation or environmental stressors such as elevated temperatures, or flood flows.

Relative humidity
The amount of water vapor in the air, compared with complete saturation. If relative humidity is greater than 100%, the vapor will tend to condense to liquid, until 100% is reached.

Residualization
The process by which an anadromous steelhead foregoes smoltification and maintains a resident, freshwater life-history.

Riffle
Shallow section of a stream or river with rapid current and surface broken by gravel, ruble, or boulders.

Run
Swiftly flowing stream reach with little surface agitation, and no major flow obstructions.

Salmonids
Fish of the taxonomic family Salmonidae that includes salmon, trout, whitefish, and char.

Seasonal Lagoon
An estuary that becomes separated from the ocean by a sandbar barrier for part of the year.

Sea Level Rise
The rise in average sea level elevation with respect to current terrestrial elevations. Increasing sea level is the result of increasing temperatures causing the thermal expansion of water and the addition of water to the oceans from the melting of mountain glaciers, polar ice caps, and Greenland and Antarctic ice sheets.

Sediment
Fragment of rock, soil, and organic matter transported and deposited in beds by wind, water, or other natural phenomena. The term can refer to any size of particles but is often used to indicate only fragments smaller than 6 mm.

Sedimentation
Deposition of material suspended in water or air, usually when the velocity of the transporting medium drops below the level at which the material can be supported and moved.

Sediment Loading
The total sediment in a stream system, whether in suspension (suspended load) or on the bottom (bed load).

Semelparous
Organisms which reproduce only once. The single reproductive event of semelparous organisms is usually large, as well as fatal. An example of a semelparous organism is the Pacific salmon (*Oncorhynchus* spp.), which live for several years in the ocean before migrating to the freshwater stream of its birth, laying eggs, and dying.

Sink Population
A local population that has a negative growth rate, or a high probability of periodic extinction; its continued persistence is dependent upon immigration from other local populations, or dispersal from more remote populations.

Smolt
A young salmon or steelhead that is undergoing physiological changes in preparation for entering the ocean.

Smoltification
The suite of physiological, morphological, biochemical, and behavioral changes, including the development of the silvery coloration and tolerance of saltwater, which takes place in salmonid parr as they prepare to migrate downstream to the ocean.

Source Population
A local population that has a sufficiently high growth rate when small to persist even without immigration from other local populations, or dispersal from more remote populations.

Spawning Density
The number of potentially spawning individual in a length of stream, tributary, or some other hydrologic unit.

Steelhead
A rainbow trout (*Oncorhynchus mykiss*) that exhibits an anadromous life cycle.

Stochastic
The state where a system's components are affected by random variability. A stochastic model is a model whose behavior is not fully specified by its form and parameters, but which contains an allowance for unexplained effects represented by random variables.

Stratification
The establishment of distinct layers of temperature or salinity in bodies of water such as an ocean, lake, or estuary, based upon the different density of warm and cold water or saline or freshwater.

Stream Order
A numerical designation (from 1 to 6 or higher) that designates the relative position of a stream or stream segment in a drainage basin from headwaters to the rivers downstream terminus.

Substrate
Mineral or organic material that forms the bed of a river or stream.

Sustainable Fishery
A fishery that does not cause or lead to undesirable changes in the biological and/or economic productivity, biological diversity, or ecosystem structure and functioning from one human generation to the next.

Taxon
Any named group of organisms at any taxonomic level (*e.g.*, Phylum, Order, Class, Genus, Species, Sub-species, etc.).

Temperature Lapse Rate
The rate of decrease in temperature with altitude in the stationary atmosphere at a given time and location.

Thalweg
A line connecting the deepest parts of a river or stream channel.

Thermocline
A region below the surface layer of the sea or lake, or pool where the temperature gradient increases abruptly (*i.e.*, where temperature decreases rapidly with increasing depth). It is often an ecological barrier, and its oscillations have significant consequences on the distribution of organisms.

Total-Length (TL)
The length of a fish defined as the straight-line distance from the tip of the snout to the tip of the tail (caudal fin) while the fish is lying on its side normally extended.

Triploid
An organism having three sets of chromosomes.

Trophic Level
The position an organism or species occupies in the food chain, or web. A food chain represents a succession of organisms that eat other organisms and are, in turn, eaten themselves. The number of energy transfer steps is from the start of the chain is a measure of its trophic level. Food chains start at trophic level 1 with primary producer such as plants, move to herbivores level 2, predators at level 3 and typically finish with carnivores or predators at level 4 or 5 determined by the number of energy-transfer steps to that level.

Upwelling
An oceanographic phenomenon that involves wind-driven motion of dense, cooler, and usually nutrient-rich water towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water. The increased availability in upwelling regions results in high levels of primary productivity and thus fish growth and abundance. Wind-driven currents are diverted to the right of the winds in the Northern Hemisphere and to the left in the Southern Hemisphere. When surface water transport is occurring away from the coast, surface waters are replaced by deeper, colder, and denser water.

Viable Salmonid Population
An independent population of any Pacific salmonid (genus *Oncorhynchus*) that has a negligible risk of extinction due to threats from demographic variation (such as population size or sex ratio), local environmental variations, and genetic diversity changes over a 100-year time frame.

Viability Population Parameters
The four measurable characteristics of a viable salmonid population: abundance, growth rate, spatial structure, and diversity (including genetic, phenotypic diversity).

Volitional Fish Passage
The natural movement of fish in response to cues such as natural flow patterns or water temperature, or natural physiological changes in individuals.

Water Table
The irregular surface of contact between the zone of saturation and the zone of aeration; that surface of a body of unconfined groundwater at which the pressure is equal to that of the atmosphere.

Weathering
The physical/chemical processes in which a material is broken down through exposure to the atmospheric conditions (heat, water, etc.)

Winter-Run Fish
Anadromous fish that return to freshwater in the autumn or winter, migrating to spawning areas, and then spawn in later winter or spring.

Young-of-the Year
Juvenile fish that are less than a year old (and are in their first year of growth).

Abbreviations

AMCES	AmeriCorps Environmental Stewards
AMBAG	Association of Monterey Bay Area Governments
AC	Audubon California
ACOE	Army Corps of Engineers
ACWA	Association of California Water Agencies
AFRP	Anadromous Fish Restoration Program
AG	Arroyo Grande
ASRA	Arroyo Seco River Alliance
BSLT	Big Sur Land Trust
BIA	Bureau of Indian Affairs (United States)
BLM	Bureau of Land Management (United States)
BMPs	Best Management Practices
BOR	Bureau of Reclamation (United States)
BPG	Biogeographic Population Group
BRT	Biological Review Team
CAWC	California-American Water Company
CCCOM	California Coastal Commission
CCCON	California Coastal Conservancy
CCCORP	California Conservation Corps
CDSOD	California Division Safety of Dams
CDFG	California Department of Fish and Game
CDF&FP	California Department of Forestry and Fire Protection
CDOT	California Department of Transportation
CDPR	California Department of Parks and Recreation
CDMG	California Division of Mines and Geology
CESA	California Endangered Species Act
CNPS	California Native Plant Society
COC	Chemical of Concern
CRPP	California River Parkway Program
CSFPR	California Sport Fishing Protective Association
CSWMB	California State University, Monterey Bay
CT	California Trout
CCSD	Cambria Community Service District
CAWD	Carmel Area Wastewater District
CRA	Carmel River Association
CRLC	Carmel River Lagoon Coalition
CRSA	Carmel River Steelhead Association
CRWC	Carmel River Watershed Conservancy
CRWCO	Carmel River Watershed Council
CVPOA	Carmel Valley Property Owners Association
CCRCDC	Central Coast Resource Conservation and Development Council
CCSE	Central Coast Salmon Enhancement, Inc.
CHEER	Coastal Habitat, Education, and Environmental Restoration
CSLRCD	Coastal San Luis Resource Conservation District
CI	Confidence Interval

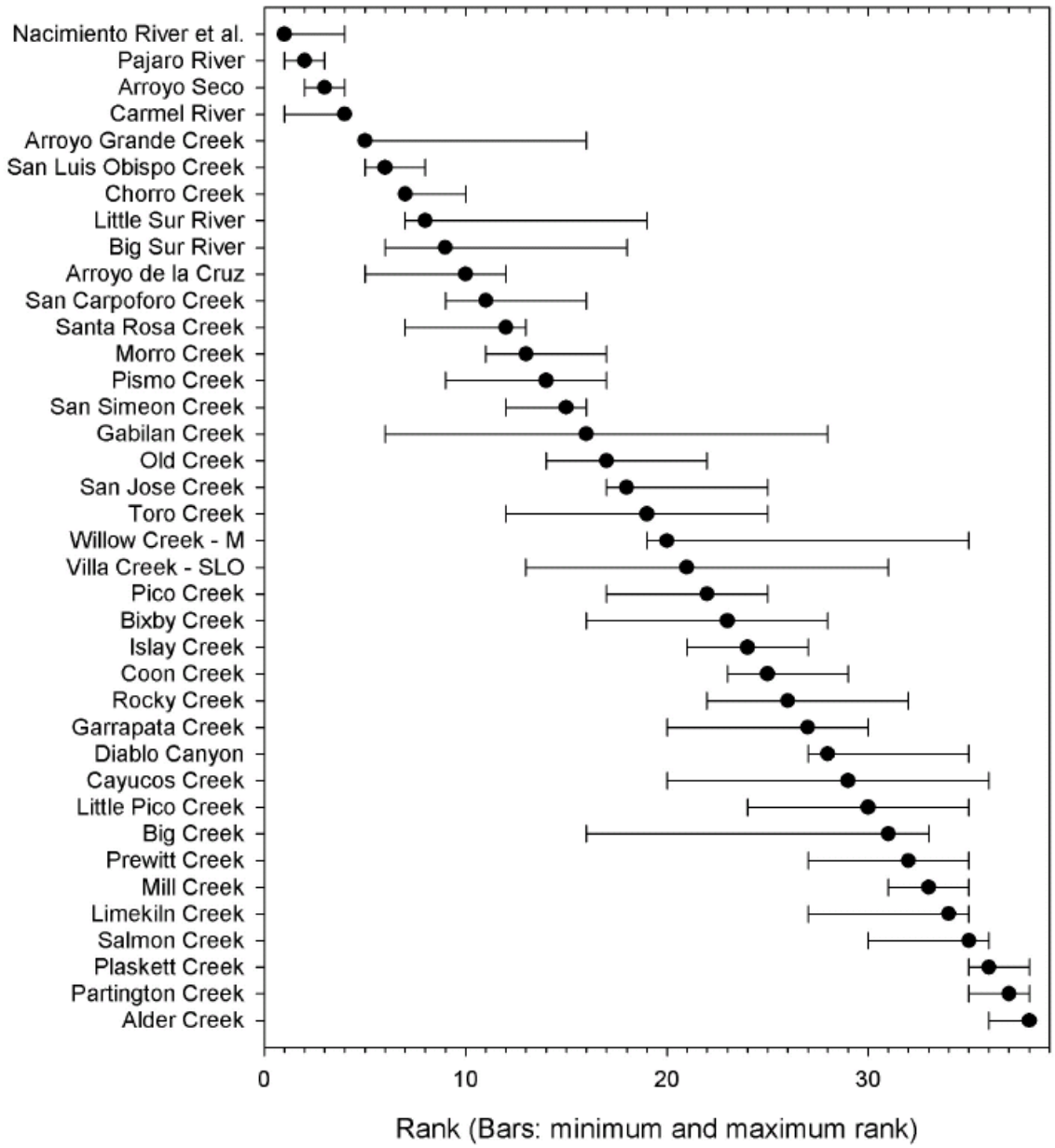
CMARP	Comprehensive Monitoring Assessment and Research Program
C^0	Centigrade
cm	Centimeters
cm/sec	Centimeters per second
COA	City of Atascadero
COC	City of Carmel
COM	City of Monterey
COMB	City of Morro Bay
COG	City of Gilroy
COPS	City of Paso Robles
COPB	City of Pismo Beach
COS	City of Salinas
CSLO	City of San Luis Obispo
COSM	City of San Miguel
COW	City of Watsonville
CV	Coefficient of Variation
CWT	Coded Wire Tag
DOT	Department of Transportation (United States)
DIDSON	Dual-Frequency Identification Sonar
DPS	Distinct Population Segment
DWR	Department of Water Resources (State of California)
EPA	Environmental Protection Agency (United States)
EFH	Essential Fish Habitat
EII	Earth Island Institute
ENSO	El Nino/Southern Oscillation
ESF	Elkhorn Slough Foundation
ESA	Endangered Species Act (United States)
ESU	Evolutionarily Significant Unit
FEMA	Federal Emergency Management Agency
FERC	Federal Energy Regulatory Commission
FL	Fork Length
FOR	Friends of the River
FRGP	Fisheries Restoration Grant Program
ft/sec	Feet per second
GCWC	Garrapata Creek Watershed Council
HCP	Habitat Conservation Plan
IRWMP	Integrated Regional Watershed Management Plan
km/hr	Kilometers per hour
LPFW	Los Padres Forest Watch
m	Meters
mi^2	Square miles
m/sec	Meters per second
mm	Millimeters
TBD	To Be Determined
TNC	The Nature Conservancy
MC	Monterey County
MCWD	Marina Coast Water District

MOU	Memorandum of Understanding
MBMMS	Monterey Bay National Marine Sanctuary
MBSTP	Monterey Bay Salmon and Trout Project
MCPW	Monterey County Public Works Department
MCSA	Monterey County Service Area 50
MCWRA	Monterey County Water Resources Agency
MPWMD	Monterey Peninsula Water Management District
MRPD	Monterey Regional Park District
MCUSA	Monterey County Unified Sportsmen Association
NGO	Non-Governmental Organization
NFWF	National Fish and Wildlife Foundation
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
NPSPWRO	National Park Service, Pacific Western Regional Office
NRCS	National Resources Conservation Service
PCSRF	Pacific Coastal Salmon Recovery Fund
PITT	Passive Integrated Responder Tags
ppt	Parts per thousand
PBCSD	Pebble Beach Community Services District
PCLF	Planning and Conservation League Foundation
PVA	Population Viability Analyses
RFID	Radio Frequency Identification
RM	River Mile
RST	Rotary Screw Trap
RWQCB	Regional Water Quality Control Board
RCDMC	Resource Conservation District of Monterey County
RCDSC	Resource Conservation District of Santa Cruz County
SBC	San Benito County
SBCWD	San Benito County Water District
SCC	Santa Clara County
SCRC	Santa Cruz County
SCVWD	Santa Clara Valley Water District
SLP	Santa Lucia Preserve
SLOC	Santa Luis Obispo County
SWP	State Water Project
SWRCB	State Water Resources Control Board
TBSLT	The Big Sur Land Trust
TCLT	The Cambria Land Trust
TLCSLOC	The Land Conservancy of San Luis Obispo County
TBD	To Be Determined
TCFT	Tri-County Fish Team
TL	Total Length
TRT	Technical Recovery Team
TU	Trout Unlimited
TWC	The Wildlands Conservancy
TWI	The Watershed Institute (California State University, Monterey Bay)
USLTRCD	Upper Salinas-Las Tablas Resources Conservation District

USWC	Upper Salinas Watershed Coalition
USFS	United States Forest Service
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VWA	Ventana Wilderness Alliance
VSP	Viable Salmonid Population
USA	United States Army (Fort Hunter Liggett)
WCB	Wildlife Conservation Board (State of California)

APPENDIX B
Watershed Intrinsic Potential Rankings

Watershed rankings in the South-Central California Coast Steelhead DPS.[1] These rankings are based on the amount of potential habitat as in indicator of potential viability. Watersheds are ranked on the single habitat model that is preferred on *a priori* biological grounds. Horizontal bars show the range of ranks (minimum and maximum) for 48 variant biological models (See Boughton *et al*. 2006).



Bars indicate the range of ranks (minimum and maximum) for 48 variant models. (See Boughton *et al*. 2006).

APPENDIX C

COMPOSITION OF SOUTH-CENTRAL CALIFORNIA RECOVERY PLANNING AREA STEELHEAD BPGs

Watersheds identified within each of the four Biogeographic Populations Groups in the South-Central California Coast Steelhead DPS essential components of a recovery DPS. The identified watersheds are based on a combination of factors, including: 1) the amount of potential habitat as in indicator of potential viability, 2) potential diversity of life-history strategies exhibited by populations[1] within the watersheds, and 3) the diversity of habitat types within the watersheds. Additionally, the composition of watersheds addresses the need to ensure survival of a suite of populations within the DPS in the face of natural catastrophic events such as wildfires, droughts, and debris flows, through minimum spatial separation between and redundancy of watersheds/populations within each BPG. Watersheds are ranked on the single habitat model that is preferred on *a priori* biological grounds. Horizontal bars show the range of ranks (minimum and maximum) for 48 variant biological models (See Boughton *et al*. 2006, 2007).

Biogeographic Group	Member Populations (ordered north to south)
Interior Coast Range	Pajaro River, Gabilan Creek, Arroyo Seco, Upper Salinas Basin.
Carmel Basin	Carmel River
Big Sur Coast[1]	San Jose Creek, Malpaso Creek, Garrapata Creek, Rocky Creek, Bixby Creek, Little Sur River, Big Sur River, Partington Creek, Big Creek, Vicente Creek, Limekiln Creek, Mill Creek, Prewitt Creek, Plaskett Creek, Willow Creek (Monterey Co.), Alder Creek, Villa Creek (Monterey Co.), Salmon Creek.
San Luis Obispo Terrace	San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, Pico Creek, San Simeon Creek, Santa Rosa Creek, Villa Creek (SLO Co.), Cayucos Creek, Old Creek, Toro Creek, Morro Creek, Chorro Creek, Los Osos Creek, Islay Creek, Coon Creek, Diablo Canyon, San Luis Obispo Creek, Pismo Creek, Arroyo Grande Creek.

[1] Population delineations in these groups may be split too finely if there is significant dispersal of fish among neighboring coastal watersheds. For discussion see Boughton *et al.* 2006.

APPENDIX D

SOUTH-CENTRAL CALIFORNIA COAST STEELHEAD RECOVERY PLANNING AREA THREATS ASSESSMENT (CAP WORKBOOK) METHODOLOGY

Introduction

The Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) contracted with Hunt & Associates Biological Consulting Services to provide technical support in developing Recovery Plans for *Oncorhynchus mykiss* populations in the South-Central California Steelhead Recovery Planning Area. Hunt & Associates was tasked with reviewing existing information on *O. mykiss* habitat conditions, assessing the magnitude and extent of threats to *O. mykiss* and their habitats, and developing recovery actions across the South-Central California Recovery Planning Area. This document summarizes the methodology used to assess *O. mykiss* threats and sources of threats in South-Central California coastal watersheds from the Pajaro River in Monterey County south to, but not including the Santa Maria River, in San Luis Obispo County. Specifically, this document details the use of modified Conservation Action Planning Workbooks to assess watershed and life stage specific threats and threat sources for south-central California Coast *O. mykiss*. CAP workbooks have been developed previously for salmonid threat assessment and recovery planning for southern Oregon and northern California coast coho salmon as well as south-central and southern California steelhead. However, previous *O. mykiss* threat assessment workbooks, described in Kier Associates and National Marine Fisheries Service (2008), were not inclusive of all watersheds within the South-Central California Recovery Planning Area or all available environmental data and information. The CAP workbook analysis results presented in this recovery plan, therefore, builds on information in these earlier versions.

Methods

The Conservation Action Planning (CAP) Workbook is a database tool developed by The Nature Conservancy to identify conservation targets, assess existing habitat conditions, and identify management issues for target populations. CAP is a Microsoft Excel-based tool that facilitates the assessment of aquatic habitat quality and human-caused threats to that habitat. Once data are entered, the CAP workbook then links the observed aquatic habitat conditions to watershed conditions, provides a prioritized list of threats, and provides a summary of overall watershed health. The CAP Workbooks can be used to organize and evaluate large amounts of information on current *O. mykiss* habitat conditions and threats in selected watersheds. The CAP Workbook methodology provides a number of useful features in assessing the magnitude and extent of threats to *O. mykiss* and their habitats in that it:

- Incorporates both quantitative and qualitative (*e.g.*, professional judgment) measures of existing habitat conditions;
- Is an objective, consistent tool for tracking changes in the status of each conservation target (i.e., *O. mykiss* life-history stage) over time and between watersheds;
- Provides an overall assessment of a watershed's "health" or viability and objective comparisons to other watersheds;
- Focuses recovery actions by identifying past, current, and potential threats to *O. mykiss* and their habitats;

- Becomes a central repository for documenting and updating knowledge and assumptions about existing conditions; and
- Creates a foundation upon which recovery actions can be tracked and up-dated, based on changing current conditions.

Twenty-two coastal watersheds, encompassing 46 drainages were identified as supporting historical and extant *O. mykiss* populations within the SCCCS Recovery Area by Boughton *et al.* (2006), and were selected for threats assessment analysis. A separate CAP Workbook was created for each of the 46 component drainages (Table D-1). Information on existing *O. mykiss* habitat conditions in each watershed was gathered from a broad range of published and un-published materials, including, peer-reviewed scientific publications, technical reports, federal, state, and local planning documents, EIS/EIRs, management plans, passage barrier assessments, habitat evaluations, and field surveys, as well as information provided by NOAA-NMFS staff, and stakeholders and other interested parties at a series of public workshops held in 2007.

The CAP Workbook process uses available information in an explicit, consistent, and transparent way, to assess current habitat conditions. The CAP Workbook allows the user to input quantitative as well as qualitative (including best professional judgment) information in order to determine what existing conditions are and what healthy targets should look like. The Workbook is iterative and should be updated as additional information becomes available.

Conservation Targets: Specific "conservation targets" for analysis within a CAP workbook must be identified by the user. The conservation targets in this case were *O. mykiss* life-history stages: egg, fry, smolt, and adult. A more general conservation target, "Multiple Life Stages," was also established to allow landscape-scale land use and habitat assessment, based on information derived from GIS-based analysis of entire watersheds.

Key Ecological Attributes (KEAs): Assessing the "viability" or "health" of a particular conservation target (i.e., life-history stage) required identifying "Key Ecological Attributes" (KEA) for each target. Specific KEAs are aspects of the conservation target's biology or ecology such that if missing or severely degraded, would result in loss of that target over time. KEAs, such as substrate quality, non-native species, food availability, water quality, *etc.*, were identified for each target and measurable indicators, such as turbidity, water temperature, aquatic invertebrate species richness, presence or absence of non-native predators, miles of road/square mile of watershed, *etc.*, were identified in order to characterize existing conditions in the component watersheds. All KEAs were grouped into three categories:

- *Size*: target abundance *(e.g.*, number of adult *O. mykiss*);
- *Condition*: a measure of the biological composition, structure, and biotic interactions that characterize the target's occurrence (i.e., generally a local measure of habitat quality or composition), and;
- *Landscape Context*: an assessment of the target's environment (*i.e.*, landscape-scale processes, such as connectivity, accessibility of spawning habitat; hydrology).

Table D-1. South-Central California Steelhead Recovery Planning Area Component Biogeographic Population Groups, Watersheds, and Corresponding CAP Workbooks.

Biogeographic Population Group	Watershed (North to South)	CAP Workbook
Interior Coast Range	Pajaro River	Main stem Pajaro River
		Uvas Creek
	Lower Salinas Basin	Main stem Salinas River
		Gabilan Creek
		Arroyo Seco
	Upper Salinas Basin	San Antonio River
		Nacimiento River
Carmel River Basin	Carmel River	Carmel River
Big Sur Coast	San Jose Creek	San Jose Creek
	Garrapata Creek	Garrapata Creek
	Bixby Creek	Bixby Creek
	Little Sur River	Little Sur River
	Big Sur River	Big Sur River
	Willow Creek	Willow Creek
	Salmon Creek	Salmon Creek
San Luis Obispo Terrace	San Carpoforo Creek	San Carpoforo Creek
	Arroyo de la Cruz	Arroyo de la Cruz
	Little Pico Creek	Little Pico Creek
	Pico Creek	Pico Creek
	San Simeon Creek	San Simeon Creek
	Santa Rosa Creek	Santa Rosa Creek
	Morro Creek	Morro Creek
	Morro Bay Estuary	Chorro Creek
		Los Osos Creek
	San Luis Obispo Creek	San Luis Obispo Creek
	Pismo Creek	Pismo Creek
	Arroyo Grande Creek	Arroyo Grande Creek

Current Indicators: The range of variation found for each indicator was then subdivided into four somewhat subjective, but discrete, categories: "Poor," "Fair," "Good," or "Very Good." The current condition of a specific indicator, taken from a field measurement, literature source, or professional judgment, is assigned to one of these four discrete rating categories. A description of indicators used in the CAP steelhead analyses and the rationale for these indicators is available in Kier Associates and National Marine Fisheries Service (2008). Functionally; however, we assumed that there are essentially two states for an indicator as it relates to the target: 1) "poor-fair," in which the indicator exceeds or minimally meets the requirements for species survival and the population is in danger of extirpation, and 2) "good-very good," where habitat conditions are favorable for species persistence.

The CAP Workbook can use indicators at a local, regional, and landscape-scale. For example, land use indicators, such as density of roads per square mile of watershed, has been widely employed as a landscape-scale metric of watershed "health" for salmonids throughout the western United States (see Kier Associates and NMFS, 2008). These landscape-scale metrics were used in this threat assessment to overcome logistical and analytical problems inherent in local-scale metrics of *O. mykiss* habitat quality (*e.g.*, water temperature), that exhibit extreme spatial and temporal variation, which can lead to misinterpretations.

The goal of establishing measurable indicators in a number of instances was not possible with the current knowledge of existing habitat conditions in the component watersheds. For example, turbidity is known to be an important habitat indicator for *O. mykiss*. For the *O. mykiss* fry life stage, turbidity was defined as the "number of days turbidity exceeded 25 NTUs." Currently, there is little or no systematic and widespread collection of turbidity data in most of the subject watersheds drainages to permit a quantative assessment of this indicator. In these instances, subjective information, such as observations of mass wasting of slopes, descriptions of point and non-point sediment input, *etc.*, were used to qualitatively assess a current condition and rating for this indicator. Because the CAP Workbook analysis is iterative, results can be improved as better quantitative information becomes available.

Stresses and Sources of Stress (Threats): An important step in the CAP Workbook assessment, and the purpose of these analyses, is identification of a series of stresses to each *O. mykiss* life-history stage. These stresses are basically altered KEAs and directly affect the life-stage, *e.g.*, degraded hydrologic function, increased turbidity, presence of non-native predators, increased substrate embeddedness). Because of the lack of field derived information on specific habitat requirements (i.e., tolerances) and specific habitat conditions, the GIS-based surrogate variables used for the "Multiple Life Stages" conservation target actually are sources of stress, not direct stressors on *O. mykiss* life stages (*e.g.*, increased road density (a source of stress) contributes indirectly to increased turbidity (a direct stressor). The severity (very high, high, medium, or low) and geographic scope (very high, high, medium, and low) of each stress was determined through a review of existing information. The CAP Workbook then assigns an overall stress rank (very high, high, medium, or low) to that stress.

The CAP Workbook automatically inputs the overall rank of each stress into a table that relates the stress to a series of anthropogenic sources of stress (also called Threats) that have been identified by the user as relevant to that watershed (*e.g.*, roads, grazing practices, logging, recreational facilities, agricultural conversion of watershed lands, dams, groundwater extraction, in-channel mining, *etc.*). Each threat is ranked on the basis of its relative "contribution" (very high, high, medium, or low) and "irreversibility" (very high, high, medium, or low) to each stress (*e.g.*, increased turbidity). The CAP Workbook then ranks the threat (source of stress) as "Very High," "High," "Medium," or "Low" and inputs that rank into the next step of the assessment. This process is repeated for each conservation target (egg, fry, juvenile, smolt, and adult), as well as the "Multiple Life Stages" conservation target.

Summary of Threats: The CAP Workbook ranks the threat sources for each conservation target (i.e., life-history stage) from the previous analysis into a "Summary of Threats" table that lists all the threat sources for all life-history stages and assigns a composite "Overall Threat Rank" to each threat source (*e.g.*, dams and surface water diversions), as well as an overall threat rank to that watershed for all threat sources combined. The Workbook derives a second table ("Stress Matrix") that shows the rank of each stress on each life-history stage. The final step in the steelhead CAP assessment is the derivation of a third table entitled, "Overall Viability Summary," that ranks the viability of each life-history stage and KEA category (size, condition, and landscape context) by calculating a composite rank of the current habitat indicators from the "Viability" table of the workbook, as well as an overall "Project Biodiversity Health Rank," which is a measure of watershed "health" based on current habitat conditions. The first and third summary tables proved the most useful in analyzing stresses and sources of stress to *O. mykiss* in the SCCCS Recovery Planning Area.

Data Gaps. The tables in the CAP Workbooks for the present study have numerous blank cells. Blank cells indicate a lack of available information. Watersheds that have been intensively studied have fewer blank

cells than watersheds with few studies. However, an important feature of the CAP Workbook methodology is the ability to update the assessment as information becomes available. In the interim, professional judgment must be used to address such gaps until such time as field derived, quantitative data is available.

The CAP Workbooks analyses prepared by Kier Associates are intended to complement, not duplicate, those prepared by Hunt & Associates. During the initial stages of CAP Workbook analyses by Hunt & Associates, it was determined that, in some cases, surrogate indicators covering regional spatial scales and derived from GIS-based watershed analysis, might be useful in overcoming the spatial and temporal problems associated with habitat indicators that rely on point-data measurements (such as water temperature, turbidity, riparian corridor width and composition, *etc.*). A separate conservation target category "Multiple Life Stages" was developed for the CAP Workbook analyses that used GIS-based surrogate indicators.. Surrogate indicators, such as density of roads per square mile of watershed, density of roads within 300 feet of streams per square mile of watershed, human population density, percent of watershed converted to agriculture; percent of watershed converted to impervious surfaces, percent of watershed burned in past 25 years, and others provided a general measure of existing watershed conditions as they affect multiple steelhead life-history stages. For example, road density, especially riparian road density, and percent of watershed as impervious surface, has strong predictive power of general habitat conditions for steelhead because paved surfaces have manifold adverse effects on habitat quality, water quality, and hydrology of streams.

Hunt & Associates' workbooks are based on review of a large number and broad range of ground-based steelhead surveys, habitat and barrier assessments, and other fieldwork, as well as the GIS-based indicators for the "Multiple Life-History" target category developed by Kier Associates. Hunt & Associates developed CAP Workbooks for 73 drainages across both Steelhead Recovery Planning Areas (27 for the South-Central California Steelhead DPS and 46 for the Southern California Steelhead DPS). Kier Associates analyzed 54 drainages across both steelhead DPSs (23 for the South-Central California Steelhead DPS and 31 for the Southern California Steelhead DPS), using the GIS-based regional indicators and on a small number of point-data measurements (such as dissolved oxygen, water temperature, *etc.*). Kier Associates' workbooks are provided as a separate document (Kier Associates and NMFS, 2008).

Table D-2 compares the results of the two documents for watersheds in the SCCCS Recovery Planning Area. It should be noted that the difference between a "Poor" and "Fair" habitat rating or a "Good" and "Very Good" rating is often a matter of professional judgment and may always not represent important differences in habitat quality. Table D-2 explains discrepancies between "Poor-Fair" and "Good-Very Good" categories between the Hunt & Associates and Kier Associates CAP Workbook analyses.

Discrepancies typically could be explained by the type (point-data measurements) and the number of indicators used in the analysis by Kier Associates versus Hunt &Associates. As the number of indicators decreases, the relative weight given to each indicator in the analysis correspondingly increases, and if these indicators are based on point-data measurements, such as water temperature or dissolved oxygen, that exhibit extreme spatial and temporal variation, then different results can be obtained. Aside from these relatively few specific differences, the results of the two assessments closely agree.

Further refinement of individual threat severity and threat sources in specific watersheds was conducted for these threat assessments by using information from NOAA staff familiar with these watersheds to override certain final assessments.

Table D-2. Variation in Assessments of Overall Habitat Conditions for Steelhead in Component Watersheds in the South-Central California Steelhead Recovery Planning Area Between Two CAP Workbook Analyses*

Watershed	Steelhead Habitat Rating		Reasons for Discrepancy
	Hunt & Associates	Kier Associates	
Pajaro River			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Lower Salinas River			
Upper Salinas River			
Carmel River			
San Jose Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Garrapata Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Bixby Creek			
Little Sur River			
Big Sur River			**Difference in rating floodplain connectivity and number of available indicators used in analysis**
Willow Creek			
Salmon Creek			**Natural barrier (waterfall) in lower reach is limit of anadromy. Kier rates entire watershed as poor on this basis; Hunt & Associates rates only accessible reach.**
San Carpoforo Creek			
Arroyo de la Cruz			
Little Pico Creek			
Pico Creek			**Kier includes point measurements for dissolved oxygen for fry, juvenile, and smolt life stages (rated as "poor"); difference in number of available indicators**
San Simeon Creek			
Santa Rosa Creek			**Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life- history stage viability**

Morro Creek			
Chorro Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
Los Osos Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability
San Luis Obispo Creek			
Pismo Creek			
Arroyo Grande Creek			Minor difference in cutoff points between indicator categories; difference in number of indicators used to determine steelhead life-history stage viability

** Overall habitat condition rating taken from "Project Biodiversity Health Rank" rating in "Overall Viability Summary" table in Summary section of individual CAP Workbooks (composite rating of habitat conditions for all steelhead life-history stages combined). Watersheds analyzed only by Hunt & Associates are not shown.*

*** Pervasive discrepancies between Hunt * Associates vs. Kier Associates "poor" and "fair" categories here are due to fewer number of indicators used in the latter analyses.*

Key: dark green = very good conditions; light green = good conditions; yellow = fair conditions; red = poor conditions.

The full CAP Workbooks, with references, are available upon request to NOAA Fisheries Southwest Regional Office, Long Beach, CA.

APPENDIX E

RECOVERY ACTION COST ESTIMATES FOR STEELHEAD RECOVERY PLANNING

Introduction

The ESA provides that "recovery plans, shall, to the maximum extent practicable . . . incorporate in each plan . . . (iii) . . . estimates of the time required and the cost to carry out those measures needed to achieve the plan's goal and to achieve intermediate steps toward that goal." NMFS interim recovery planning guidance (2010) further provides that, "There may be extreme cases in which estimating the date and cost to recovery is not possible due to uncertainty in what actions will need to be taken to recover the species." The precision of any recovery cost estimate is necessarily governed by the specificity of the recovery action, and the availability of information regarding the costs of individual components of that recovery action (labor, materials, logistics, geographic scope and duration, etc.).

As noted in the Recovery Plan, there are many uncertainties regarding the recovery of South-Central California Coast steelhead, ranging from fundamental biological questions about the ecology of the species, to anticipated changes in climate. The Recovery Plan identifies categories of systemic threat sources within individual watersheds across the DPS but, because of the large number of individual threats (from site-specific activities to general land-use practices), does not provide a detailed assessment of each specific threat, and in many cases calls for further investigations to more clearly characterize and assess threats which are believed to be of particular significance for the conservation of the species (*e.g.*, fish passage barrier inventories, flows restrictions, introduction exotic species, and degradation of estuarine and other habitat types). Because of the uncertainties regarding specific aspects of the life history of steelhead (*e.g.*, relationship between anadromous vs. resident reproductive life history cycles), the Recovery Plan also provides provisional viability criteria, and identifies important research and monitoring needed to better illuminate the biological requirements of the species and thereby better refine the viability criteria, and related recovery actions.

The recovery action tables (Tables 9-4 through 13-10) developed for each BPG within the DPS identify broadly conceived recovery actions for each major threat source in all the core populations (as well as providing a priority ranking for recovery action within each core watershed). These recovery actions are based on the general recovery action descriptions contained in Chapter 8, Summary DPS-Wide Recovery Actions, Table 8.2 (Recovery Action Glossary). However, implementation of the recovery actions will require detailed background studies, and in some cases, engineering and other types of site-specific plans and/or environmental documentation, to further refine the nature, scope and other relevant details of the recovery action. Within the limits of these information constraints, an effort has been made to identify, within an order of magnitude, the estimated cost of the basic types of recovery actions.

Cost Estimation Method

The following describes the methods by which cost of individual types of recovery actions were estimated.

NMFS's Southwest Region has utilized a series of assumption tables for costs derived initially from the Southwest Region's *Habitat Restoration Cost References for Salmon Recovery Planning* (Thompson and Pinkerton 2008). These assumption tables have been adjusted to the extent practicable to reflect conditions in South-Central California Coast Steelhead DPS, and applied across the DPS.

The "Cost of Doing Business" is estimated on a staff-time basis. When staff is required for review only, the cost is attributed to the initial fiscal year; when implementation is intended, the staff time is annually attributed across the projected duration of the recovery action. All other costs are estimated on a per project, per area, or per distance basis.

Finally the cost estimates provided in the cost assumption tables are the direct costs of implementing each recovery action, and do not reflect indirect costs, or benefits (*e.g.*, benefits to the local economy stemming from restored habitats that support recreational activities, reducing flood hazards, improving water quality, etc.).

Agricultural Development

The costs for implementing a plan to minimize runoff from agricultural activities were derived by estimating the number of river or stream miles running through agriculturally-zoned or agriculturally-designated lands in each BPG using Geographic Information Systems (GIS). After applying a cost per linear mile, project costs were then projected over a twenty-year period. (See Assumptions and Categories Tables 15 and 19.)

Dams and Diversions

The costs to execute recovery actions associated with dams and diversions were calculated using the CalFish.org mapping tool. This tool allows the determination of the number of dams/diversions across the BPG and assigns costs according to passage barrier severity. While this method may be useful for small dams and diversion, the modification or removal of large dams is highly dependent on site-specific conditions and cannot be accurately estimated without extensive technical and planning studies. (Refer to Assumptions and Categories Tables 4 and 5 for cost identities).

Other Passage Barriers

Culvert replacement costs were calculated based on the assumption that a minimum of one culvert would need to be replaced in each identified watershed, or sub-watershed, annually for the first five years of Recovery Plan implementation. (See Assumptions and Categories Table)

Groundwater Management

Groundwater management costs are made based on hiring one staff scientist to assess current groundwater management practices, and identify steps, if necessary, to modify practices to address potential threats. After the first year, the scientist position is dropped to 'Cost of Doing Business". Sediment assessments are initially calculated by stream length and then on a per mile basis. (See Assumptions and Categories Tables 1, 2, and 19.)

Flood Control

The costs for levee and channelization-related recovery actions are estimated by using GIS to perform a dimensional analysis of parameters such as stream length, acreage, etc. Based on these results, costs are assigned on a per mile or per acre basis. As with large dams and diversion, while this method may be useful for facilities, the modification removal of large flood control works is highly dependent on site-specific conditions and cannot be accurately estimated without extensive technical and planning studies. Federal, state and local flood control works, as well as actions such as "minimize herbicide use near levees" are considered to be "Cost of Doing Business". (See Assumptions and Categories, Tables 1, 12 and 13.)

Mining and Quarrying

The cost estimates for aggregate mining operations are made based on hiring one staff biologist to make an initial assessment of current mining practices, and identify steps, if necessary, to modify practices to address potential threats. After the first year, the position is considered to be 'Cost of Doing Business". (See Assumptions and Categories, Tables 1 and 2).

Non-Native Species

Non-native species recovery actions consist of several distinct activities, including assessment, control, education and outreach, as well as development of monitoring programs. The costs for controlling and removing non-native species are derived on a per acre basis and a staff time scenario. The education and outreach costs are based on per program scenarios. The monitoring program costs were based on hiring a biological scientist for one year to develop a monitoring program, and then transitioning that cost into a "Cost of Doing Business" scenario. (See Assumptions and Categories, Tables 2, 17 and 18.)

Urban Development

The costs for recovery actions focused on urban development threat sources were calculated based on the hiring of an Urban Regional Planner under a staff-time scenario for the first year. To assess the adequacy of current land-use planning standards and programs, and to identify step, if necessary, to address potential inadequacies. After the first year, the cost reverts to "Cost of Doing Business". Managing effluents and storm drains were considered to be annual maintenance scenarios and "Cost of Doing Business". (See Assumptions and Categories, Table 1.)

General Planning

The costs associated with reviewing and updating General Plans or Local Coastal Plans, and more focused plans such as transportation, recreation, and water quality plans were all considered to be "Cost of Doing Business". (See Assumptions and Categories, Table 1.)

Wildfires

Public agencies are assumed to be responsible for fuel and equipment required for wildfire planning and management, as is required by the Endangered Species Act for the protection of listed species, including steelhead. Therefore, all costs associated with wildfire planning and management throughout the DPS are considered to be "Cost of Doing Business". (See Assumptions and Categories, Tables 1 and 2.)

Upslope/Upstream Activities

The costs for estuarine restoration recovery actions designed to deal with a variety of upslope/upstream activities were made on a per acre basis using a staff-time scenario. Costs are based on a combination of GIS dimensional analysis to determine currently existing estuarine areas as well as factoring in the percentage of historical estuarine area that still remains. The restoration of coastal estuaries is highly dependent on site-specific conditions and cannot be estimated without extensive technical and planning studies. (See Assumptions and Categories, Tables 2 and 16.)

Regional Cost Estimate Tables: Categories and Assumptions

Table 1. Cost of Doing Business (CDB)

Action Type	Cost Representation
CDB: Enough Staff Available	0
CDB: Inadequate Funding/Staff	0[1]
Over and Above CDB	FTEs[2]

[1]Defer to IRM action where additional FTEs accounted for
[2] See Bureau of Labor Statistics, FTE assumption table (2008) for costs.

Table 2. Staff Time[2]

Occupation	Wage[1] ($/hr.)	Annual Wage ($/FTE)
Biologist	33	68030
Biologist Technician	20	40900
Fish and Game Warden	27	56030
Police/Sheriff Patrol Officers	25	52810
Forest Fire Inspectors/ Prevention	18	36400
Forest and Conservation Workers	13	26110
Urban and Regional Planners	30	62400
Physical Scientists (all others)	44	91850

[1] Seasonal
[2] Source: Bureau of Labor Statistics, 2009

Table 3. Groundwater Management[1]

Action	Cost ($/gage) & ($/year)
Installation of State/Private Gage	26136
Installation of USGS Gage	29545
Annual Maintenance of State/Private Gage	7955
Annual Maintenance of USGS Gage	3409

[1] Source: Dem-WRB Streamflow Committee, 2004

Table 4. Fish Passage Improvement ($/Project)[1]				
Stream Crossing	Land Use			
	Forest	Agriculture	Suburban	Urban
Tributary: Total Barrier	63,636	159,090	318,181	556,818
Tributary: Partial/Temporal Barrier	31,818	79,545	159,090	278,409
Stream : Total Barrier	159,090	381,818	556,818	795,454
Stream: Partial/Temporal Barrier	79,545	190,909	278,409	397,727

[1]Source: CDFG 2004 (p. 1-16)

Table 5. Dam Removal[1]	
Dam Height	Cost ($/foot)
< 15'	568,181
>15'	17,045
unknown height: complete barrier	1,022,727
unknown height: partial/temporal/unknown barrier	511,363

[1] Source: CDFG 2004 (p. I.11)

Table 6. Bridge Construction[1]	
Bridge Type	$/sq. ft. of decking
RC Slab	191
RC Box Girder	170
CIP/PS Slab	168
CIP/PS Box Girder	298
PC/PS "I" Girder	231
PC/PS Bulb "T" Girder	239
Average	216

Source: DOT, 2008.

Table 7. Replacing a Culvert	
New Type of Crossing	Average Cost ($)
Bridge <40ft	51,546
Bridge >40ft	103,093
Bottomless/Open Bottom Arch	193,961
Natural Bottom Pipe Arch	215,776
Box Culvert	248,352

Source: NMFS 2008, p. 11-15

Table 8a. Road Upgrade/Road Decomissioning[1]	
Location	**Cost ($/mile)**
California	18,104
California	93,279
Table 8b. Road Construction (for relocation purposes)[2]	
Type of Road	**Cost ($/mile)**
Non paved: two directional 12' shared path	175,000
Undivided 2-lane rural road w/ 5' paved shoulders	1,713,000

[1] Source: NMFS 2008, p. 43-44
[2] Source: DOT 2010

Table 9. New Fish Ladder[1]	
Waterway Size	**Cost ($)**
Large	1,022,727
Small	568,181

[1] Source: NMFS 2008, p. 9

Table 10. Culvert Replacement ($/Culvert)[1]				
Size of Waterway	**Road Type**			
	Forest Road	**Minor 2 Lane**	**Major 2 Lane**	**Hwy 4+ Lane**
Small (0-10')	31,976	87,209	174,419	319,767
Medium (10-20')	87,209	220,930	319,767	436,047
Large (20-30')	133,721	267,442	406,977	813,953

[1]Source: NMFS 2008, p. 10

Table 11. Storm Drain Retrofit[1]	
Action	**Cost ($/filter) or ($/program)**
Catch Basin/Filter Installation	98
Annual Maintenance Program	6452

[1]Source: Kosciusko County 2002

Table 12. LWD/Instream Restoration[1*]	
Stream Type	**Cost ($/mile)**
Small, Rocky	68,182
Large, Rocky	159,091

[1]Source: CDFG 2004, p. 1.23 – 1.24
**includes 5 yrs. of monitoring/maintenance and 10% administrative fee*

Table 13. Channel Restoration[1]	
Type	**Cost ($/mile)**
Large scale reach restoration	4,217,623

[1]Source: NMFS 2008, p. 27

Table 14. Riparian Planting			
Materials/Site Accessibility	**Site Preparation Costs ($/acre)[1]**		
	Flat/Light Clearing	**Average Clearing**	**Steep/Heavy Clearing**
Low Cost	17,442	40,698	93,023
Medium Cost	26,163	63,954	110,465
High Cost	46,512	78,488	1,366,279

[1] Source: NMFS 2008, p. 32

Table 15. Bank Stabilization[1]	
Distance From Road (miles)	**Cost ($/foot)**
0.25 - 0.5	284
0.5 - 1	313
1 - 2	341
2 - 3	369
> 3	398

[1]Source: NMFS 2008, p. 38

Table 16. Estuary Restoration[1]	
Project Type	**Cost ($/acre)**
Small: tide gate removal, culvert upgrade, tidal salt marsh restoration	6000
Medium: automated tide gates, culverts, 500 feet of new dikes	67000
Large: automated tide gates, excavation of fill, re-vegetation	20000

[1]Source: Coastal Resources Management Council 2010

Table 17. Education and Outreach Programs[1]	
Type	**Cost ($)**
General Education and Outreach	76,136
Coho Specific Education	55,682

[1] Source: CDFG 2004, p. 1.42

Table 18. Removal of Invasive Plant Species	
Invasive Species	**Cost ($/acre)**
Average	8028

[1]Source: Neil 2002
[2]Source: Bennet 2007 (average cost)
[3]Source: U.S. FWS 2001
[4]Source: Northern California Conservation Center 2010

Table 19. Sediment Assessments[1]	
Location	**Cost ($/mile)**
Average all assessments in CA	1,240

[1]Source: NMFS 2008, p. 61-62

BPG: Core 1 and 2 Population Cost Estimate

BPG	FY 1-100 Total Costs	Core 1 Populations	Core 1 FY 1-100 Costs	Core 2 Populations	Core 1 + 2 FY 1-100 Costs
Interior Coast Range	242,520,445	Pajaro River Salinas River	96,590,000	No Core 2 populations Identified	N/A
Carmel River Basin	114,797,765	Carmel River	114,797,765	No Core 2 populations Identified	N/A
Big Sur Coast	11,213,090	San Jose Creek Little Sur River Big Sur River	6,860,035	Garrapata Creek Bixby Creek Willow Creek Salmon Creek	4,353,055
San Luis Obispo	195,751,920	San Simeon Creek Santa Rosa Creek Pismo Creek San Luis Obispo Creek Arroyo Grande Creek	80,471,285	San Carpoforo Arroyo de la Cruz Little Pico Creek Pico Creek Morro Creek Morro Bay Estuary (Chorro Creek, Los Osos Creek)	115,280,635

Table 20. BPG: Core 1 and 2 Population Cost Estimates

Funding Recovery Actions

Many of the recovery actions identified in the recovery action tables are intended to restore basic ecosystem processes and function such as more natural hydrologic conditions, water quality, and riparian and estuarine habitats. These actions will, in many cases, serve to restore multiple native species and associated human uses of these natural resources. As a result, such activities may be eligible for funding from multiple funding sources at the federal, state, and local levels.

Federal funding sources include:

- NOAA/ NMFS Restoration Center Community-Based Restoration Program
  NOAA/ NMFS Restoration Center Open Rivers Initiative
- NOAA/ NMFS Proactive Species of Concern Grant Program
- NOAA National Sea Grant College Program
- NOAA Coastal and Estuarine Land Conservation Program
- NOAA/ ACOE/ USFWS/ EPA/ NRCS Estuary Habitat Restoration Program
- EPA Wetlands Protection Grants and Near Coastal Waters Programs
- US. Department of Transportation Highway Bridge Rehabilitation and Replacement Program
- U.S. Fish and Wildlife Service National Coastal Wetlands Conservation Grant Program
- U.S. Fish and Wildlife Service Coastal Program
- U.S. Fish and Wildlife Service Partners for Fish and Wildlife Program
- U.S. Fish and Wildlife Service North American Wetland Conservation Act

- National Resource Conservation Service
- Federal Highway Administration – Road Aquatic Species Passage Funding

State funding sources include:

- California Department of Fish and Game Pacific Coast Salmon Restoration Fund
- California Coastal Conservancy Proposition 84 Funds
- California Coastal Conservancy Community Wetland Restoration Grants
- California Wildlife Conservation Board
- California State and Regional Water Quality Control Board Clean Water Grant Program
- California Integrated Watershed Management Grant Program Proposition 50 Funds
- California Department of Parks and Recreation Habitat Conservation Fund
- CalTrans Environmental Enhancement and Mitigation Program
- U.C. California/ NOAA California Sea Grant College Program

In addition to federal and state funding sources, there are also numerous private national, regional and local funding sources for South-Central California habitat restoration projects, such as:

- National Fish and Wildlife Foundation

Many of these grant programs also offer technical assistance, including project planning, design, permitting, monitoring. Additionally, regional personnel with NOAA, California Department of Fish and Game, and the U.S. Fish and Wildlife Service can provide assistance and current information on the status of individual grant programs.

APPENDIX F

Pesticide Application Best Management Practices

Application of pesticides requires site specific assessment, taking into account a variety of factors including the nature and density of the pest to be controlled, the timing, weather and soil conditions, the proximity to water courses, drainage patterns, and the sensitivity of species not targeted for control or elimination through the application of pesticides. Listed below are a number of best management practices and considerations intended to guide the application of pesticides in watersheds supporting anadromous fishes. For up-to-date information on pesticide use in California see California Department of Pesticide Regulation 2012a, 2012b:

- Select the lowest toxicity pesticide necessary to control the targeted species. Research the products by consulting Material Safety Data Sheets, EPA registration documents, or other sources of information that provide ecological toxicity data (e.g. No Observable Effect Concentrations (NOEC), Lethal Concentration 50% (LC50)). Avoid using materials for which such data is unavailable.
- Apply pesticides in a manner that prevents migration from the application area and exposure of listed anadromous fish and their habitat components (*e.g.,* aquatic invertebrates or native riparian plant species).
- Applications within riparian areas (*e.g.,* for invasive plant control) should be made with backpack sprayers, hand-held wands or other devices that give the applicator maximum control of the spraying. If this is not possible, apply the product using the largest droplet size possible to control drift. Have a dedicated observer to monitor for drift of the pesticide.
- Use a non-toxic dye to assist in identifying spray coverage and pesticide drift whenever needed.
- Use a hand-held anemometer or on-site weather station to monitor wind speeds during applications. Do not rely on visual estimation methods.
- Whenever possible, apply pesticides when listed species are not present, and maximize avoidance of reproductive or juvenile life-history stages.
- Avoid indiscriminate drifting of pesticide products into riparian areas or waterways. If applying to properties adjacent to water bodies with anadromous fish, ensure sufficient riparian vegetation is present to serve as a screen against potential drift.
- Utilize aquatic approved formulations of pesticides rather than terrestrial formulations in riparian areas or where pesticide drift into a water body may occur.
- Capture all runoff from areas using higher levels of pesticides (*e.g.*, some agricultural crops, golf courses) and retain the runoff long enough for the pesticides to degrade to safe levels.

Treat runoff if necessary through aeration or other means. Settle out and retain sediments, if possible, for selected pesticides.

- Use non-chemical control methods (e.g., cleaning orchards of fallen or leftover fruit to prevent overwintering of pests) to minimize pesticide applications.
- Monitor for pests before spraying to ensure that the application of pesticides is necessary.
- Avoid adding adjuvants such as surfactants (e.g., R-11, polyoxyethyleneamine (POEA)) or synergists (e.g., piperonyl butoxide (PBO), N-octyl bicycloheptene dicarboximide (NGK 264)) to the pesticides' active ingredients unless toxicity information for these adjuvants is known and they can be safely used. Adjuvants may be more toxic to nontarget organisms such as fish and aquatic invertebrates than the pesticide active ingredient itself.
- To select the least toxic alternative, research the toxicity of adjuvants in a manner similar to the pesticide active ingredient.
- Avoid broadcast applications of pesticides to large areas or areas bordering impermeable surfaces. Utilize spot treatments.
- Promote careful use of granular formulations of pesticides when they are needed, especially by the general public. Pesticide concentrations are often highest immediately downstream of urbanized areas. Replace granular applications with other methods (e.g., spot treatments for weeds, spraying around the foundation of a building as an insect barrier rather than treating the entire property).
- Avoid the application of pesticides within 48 hours of predicted rain. (This timeframe may vary greatly depending upon the pesticide selected.)
- Avoid "water-in" granular pesticides to lawn or turf applications if another application type (e.g., spray products) can be utilized. Avoid generating pesticide runoff.
- Avoid planting or promoting known invasive plants such as Giant Reed (*Arundo donax*), Tamarisk (*Tamarix ramosissima*), Water primrose (*Ludwigia uruguayensis*), Water hyacinth (*Eichhornia* spp.), German ivy (*Senecio mikanioides),* Creeping myrtle or Common periwinkle (*Vinca* minor), Pampas grass (*Cortaderia jubata*), Spanish broom *(Spartium junceum*), *etc*. that frequently become the target of control programs using herbicides.

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