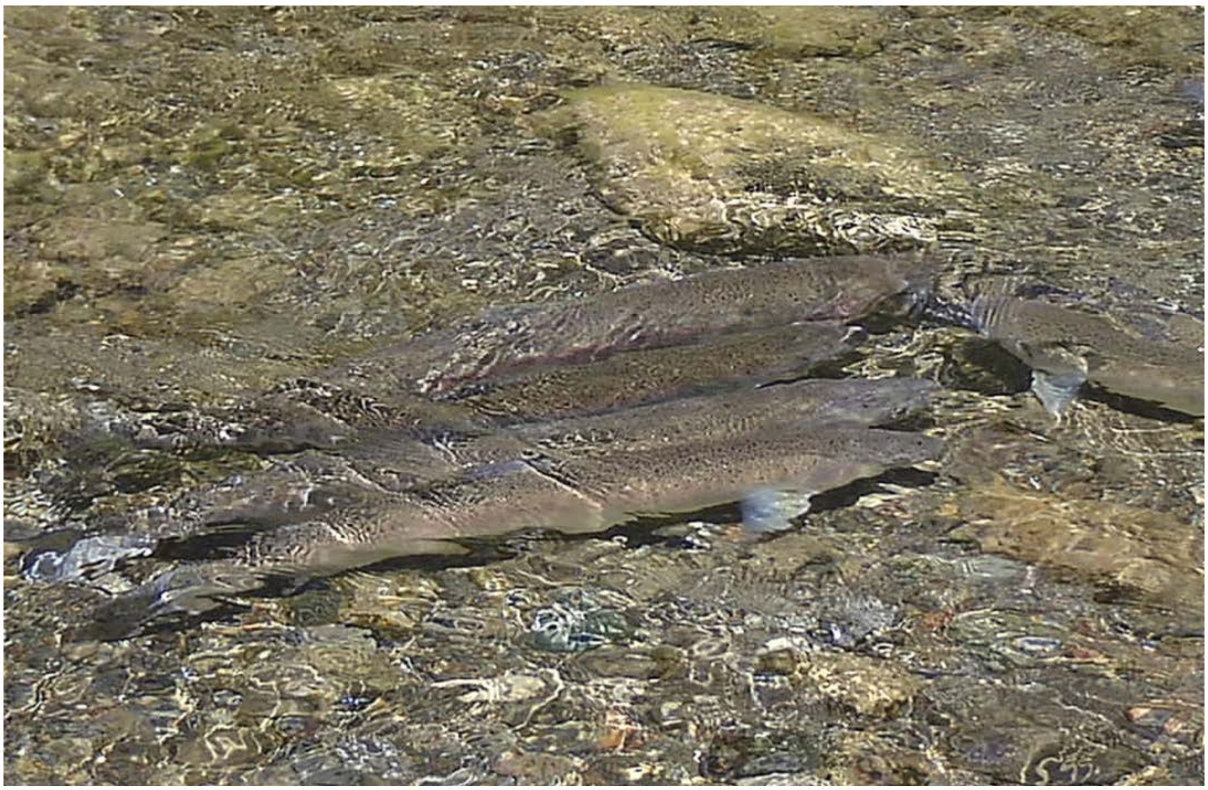
SOUTH-CENTRAL CALIFORNIA STEELHEAD RECOVERY PLAN



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http://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/south_central_southern_california_coast/south_central_southern_california_salmon_recovery_domain.html

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Steelhead

Incipient summer, scorch of the sun,
And the great steelhead shows up in our creek.
He lies in a pool, the shallow basin of a thin rock weir,
Impassively waiting. Ten days go by
And still he lingers. His presence
Is inscrutable. No one around here
Recalls such a thing: steelhead
Landlocked in summer.

For the tag-end of April
Sees the last of them. Unlike all salmon,
Rising in winter to die at the spawn,
Steelhead commonly wrig back to sea,
Reclimbing the river-path year after year:
Continuous the trek, the journey joined;
Indomitable the will, the life-thrust.

Bull this? This aberration?
What is its meaning, and why here?
Deeper hideouts, below and above,
Where salmon and steelhead alike at the spawn
Await their time—those same deep holes
Are perfect places to bide out the drought
Were such his purpose. But no. Dangerously exposed,
In window-pane water he lies alone,
And waits. Inexplicably waits.
. . . . .

William Everson

TABLE OF CONTENTS

List of Figures

Note: Unless otherwise indicated, all photographs were taken by Mark H. Capelli, South-Central/Southern California Steelhead Recovery Coordiantor, National Marien Fisheries Service, or are from the Mark H. Capelli Southern California Steelhead Watershed Archive, Donald E. Davidson Library, University of California, Santa Barbara.

List of Tables

Appendices

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 ensure a sustainable South-Central California steelhead sport fishery through the restoration of a suite of viable steelhead populations across the SCCCS DPS.*

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 prior to 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 and riparian habitats. In South-Central California, near the southern limit of the range for anadromous *O. mykiss* in North America, it is estimated that annual average 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). These historic annual run sizes varied significantly, perhaps by one or two orders of magnitude, depending on the annual rainfall patterns and longer term oceanic and climatic cycles. The present annual run sizes, also exhibit large inter-annual fluctuations, although at much lower levels.

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. However, the development of a recovery plan is only the beginning of the recovery process. Implementation of recovery plans will require the development of site-specific and project specific information, and involvement of interested stake-holders to ensure that recovery actions are effective and sustainable.

The SCCCS DPS encompasses *O. mykiss* populations in watersheds from the Pajaro River (at the boundary between Santa Cruz and Monterey Counties) 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, as well as 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 ranges 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 habitat 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 does not necessarily require restoring watersheds to a pre-development, pristine state, but restoring riverine functions to the point that they support viable populations of wild steelhead.

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).

To focus recovery efforts and facilitate the recovery of the species, the SCCCS Recovery Plan identifies populations essential to meeting recovery goals and criteria (Core 1, 2, and 3 populations) in each of the four BPGs within the SCCCS DPS, and prioritizes recovery actions for each of the watersheds within these BPGs (see Recovery Action Tables in Chapters 9-12).

Recovery Strategy

Restoring the diversity of steelhead habitats (and access to them) that was previously available to steelhead within coastal watersheds is central to the recovery of the SCCCS DPS. Such a strategy aims to restore the natural selective regime under which steelhead evolved their diversity, and which is a key to the species' long-term survival.

Recovery of South-Central California steelhead will require a scientifically based biological, recovery strategy as well as effective implementation. 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, Beechie and Bolton 1999; Boughton 2010a, Naiman *et al.* 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 SCCCS Recovery Planning Area. Threats assessments for the species indicate that recovery actions related to changes in water storage and management regimes and the modification of fish passage barriers and 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

Restoring flows, access to spawning and rearing habitats, and instream habitat conditions (including estuarine conditions) necessary to support steelhead are the principal recovery actions identified in this Recovery Plan to restore the SCCCS DPS, and will require continuing active management in a region with a large human population and extensively developed land-uses.

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 address watershed-wide processes which are also the focus of other local, state and federal programs (*e.g.*, wild-fire cycle, erosion and sedimentation, runoff and waste discharges) which will benefit a wide variety of native species (including federally listed species or species of special) by restoring natural ecosystem functions. Some of the listed species which co-occupy coastal watersheds with South-Central California steelhead include: Tidewater goby (*Eucyclogobius newberryi*), Foothill yellow-legged frog (*Rana boylii*), California least tern (*Sterna antillarum browni*), California red-legged frog (*Ran aurora draytonii*), Southwestern pond turtle (*Clemmys marmorata*), Arroyo toad (*Bufo microscaphus californicus*), Least Bell's Vireo (*Vireo bellii pusillus)*), and Western snowy plover (*Charadrius alexandrinus nivosus*). Additionally, Pacific lamprey (*Entosphenus tridentata*), 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. Coordinating the implementation of recovery actions identified in this Recovery Plan with local, state and federal land use and water management programs, as well as private land owners and other interested stakeholders, is essential to the effective and timely recovery of the SCCCS DPS.

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 four 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 (Washington, Oregon, and California) and 6 million fishing trips were taken annually between 2004 and 2006 (National Marine Fisheries Service 2010c). 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 SCCCS Recovery Planning Area is challenging for a variety of reasons. These include the need to 1) refine recovery criteria which form the basis of the biological recovery strategy; 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 inherently 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 borne over the next 80 to 100 years, though many smaller scale recovery actions are projected to be completed in a much shorter time-frame. Appendix E (Estimated Costs of Recovery Actions) of the Recovery Plan contains estimates for categories of typical watershed restoration activities; it also identifies a variety of local, state, and federal funding sources to support the implementation of recovery actions

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 Wildlife, 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 is dependent on the cooperation of a variety of local, state, and federal partners, including private landowners, and non-governmental organizations working at the community and regional level. The implementation of recovery actions by these parties will require in some cases streamlining environmental review and regulatory processes to reduce costs and create incentives to landowners, non-governmental organizations, and managers undertaking recovery actions. This Recovery Plan builds on the restoration efforts which have already been made by a wide variety of local, state, and federal agencies, as well as important work undertaken by private landowners and non-governmental agencies.

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 affected 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 Wildlife, 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, U.S. Environmental Protection Agency, and the 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 (including Integrated Regional Water Management Planning efforts), and Local Coastal Plans.

Estimated Time to Recovery and Delisting

Given the scope and complexity of the threats and recovery actions identified within the SCCCS 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 Santa Cruz to Point San Luis 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*. 2012, Swift *et al.* 1993, Lufkin 1992, Nehlsen, *et al.,* 1991, Shapovalov *et al.* 1981, Capelli 1974, Boydstun 1973, Fry 1973, 1938, Combs 1972, Puckett 1970, 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 2009, 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 remaining, more highly modified watersheds such as the Salinas River and Arroyo Grande Creek watersheds (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 Wildlife 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 was 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 the SCCCS DPS as threatened in 1997, the California Department of Fish and Wildlife has ceased stocking hatchery reared fish in the anadromous waters of South-Central California (California Department of Fish and Wildlife and U.S. Fish and Wildlife Service 2010).

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 (Blakley and Barnette 1985, Brown 1945). Additionally, a significant amount of land within South-Central California coastal watersheds is protected by inclusion within State Parks and various military installations, including the upper Salinas watershed (such as portions of the Nacimiento and San Antonio Rivers) within the California Army National Guard Camp Roberts and the U.S Army's Fort Hunter Liggett.

Juvenile Steelhead, Carmel River, 1907.

NMFS's responsibility and goal is to prevent the extinction of steelhead in the wild and ensure the long-term persistence of self-sustaining 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, Boughton and Goslin 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 spread 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 41541). 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 (at the border between Santa Cruz and Monterey Counties) south to (but not including) the Santa Maria River (southern 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 Pajaro River (at the border between Santa Cruz and Monterey Counties) south to (but not including) the Santa Maria River (at the border of San Luis Obispo and Santa Barbara Counties). 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 originating 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. All listed fish are protected under the "take" provisions of Section 9 of the ESA.

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 supporting one or more life stages and containing 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 three 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 (at the border between Santa Cruz and Monterey Counties) south to (but not including) the Santa Maria River (at the border between San Luis Obispo and Santa Barbara Counties), 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 the South-Central California Coast.

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 Pajaro River (at the border between Santa Cruz and Monterey Counties) south to (but not including) the Santa Maria River (at the border between San Luis Obispo County and Santa Barbara Counties) and includes those portions of coastal watersheds that are at least seasonally accessible to steelhead entering from the ocean as well as the upstream portions of some watersheds that are currently inaccessible to steelhead due to man-made barriers. NMFS' West Coast Regional offices in Long Beach and Santa Barbara, California were 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 necessary 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; also Chapter 7, Steelhead Recovery Strategy, and Chapter 8, Summary of DPS-Wide Recovery Actions); and
- Estimates of the time and cost to carry out the recommended recovery measure (see Chapters 9 through 12, Biogeographic Population Groups, Recovery Action Tables; and Appendix E, Recovery Action Coast Estimates for Steelhead Recovery Planning).

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 2010b).

The Interim Endangered and Threatened Species Recovery Planning Guidance document (National Marine Fisheries Service 2010b) 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 12 provide a summary of the threats assessments within each of the four BPGs of the DPS. The threats assessment method is discussed in Appendix D, South-Central California Coast Steelhead Recovery Planning Area Threats Assessment (CAP Workbooks) Methodology.

Finally, it should be emphasized that development of a recovery plan is the beginning of the recovery process. Implementation of recovery plans will require the development of site-specific and project specific information, and involvement of interested stake-holders to ensure that recovery actions are effective and sustainable.

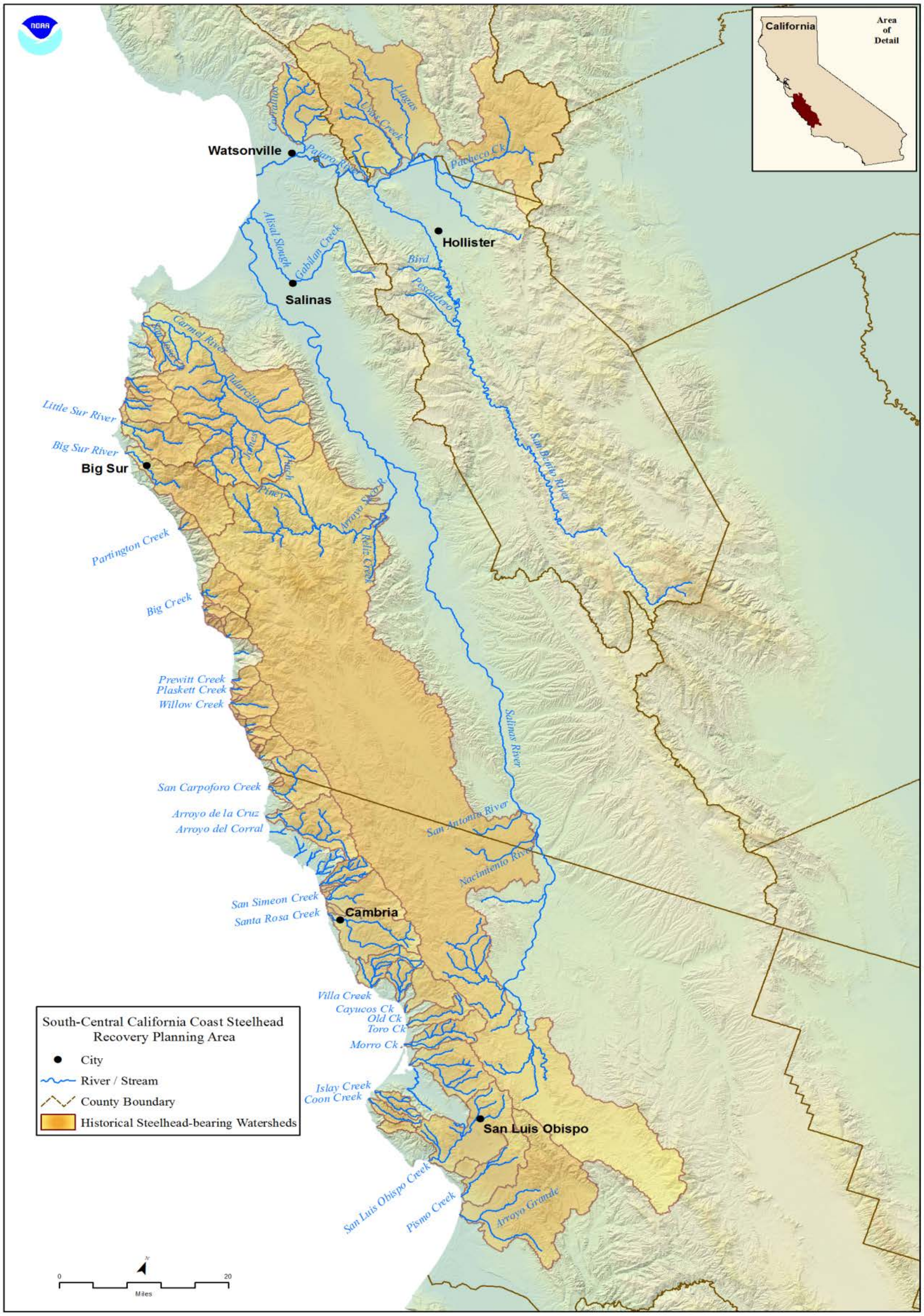

Figure 1-1. South-Central California Coast Steelhead Recovery Planning Area.

1.4.1 South-Central/Southern California Coast Steelhead Technical Recovery Team

As part of its recovery planning efforts, NMFS 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 historical 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 Fisheries Science Center – Santa Cruz, 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 Fisheries 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

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 initial development of a formal threats assessment analysis using The Nature Conservancy's Conservation Action Planning (CAP) threats assessment method, 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 Method.

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 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://www.westcoast.fisheries.noaa.gov/protected_species/salmon_steelhead/recovery_planning_and_implementation/south_central_southern_california_coast/south_central_southern_california_salmon_recovery_domain.html

NMFS released a Public Review Draft of the South-Central California Steelhead Recovery in September 2012 and held public hearings at the end of October in San Luis Obispo, San Luis Obispo County, and Monterey, Monterey County. NMFS also solicited written public comments until mid-December, and extended the comment period until June 2013 to allow the CDFW an additional opportunity to provide comments on the Recovery Plan.

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 watershed groups and private entities will 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 physiological change that allows them to migrate to and mature in salt water before returning to their natal rivers or streams (*i.e.*, where they were originally spawned) to reproduce (Benke 2002, 1992).

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*. 2012, 2011, Quinn 2005, Hendry *et al.* 2004, Hendry and Stearns 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 native 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 one to four years before returning to freshwater to reproduce (Jacobs *et al.* 2011, Beakes *et al*. 2010, Borg 2010, Haro *et al*. 2009, Leder *et al.* 2006, Quinn 2005, Davies 1991, Groot and Margolis 1995, 1991, Martin 1995, Northcote 1958, Shapovalov and Taft 1954).

The ocean phase of steelhead has not been studied extensively, and is an important area for research. 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, Myers *et al.* 2000, 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, Myers *et al.* 1996, Groot and Margolis 1991, Burgner *et al*. 1992, 1980, McNeil and Himsworth 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 sandbar 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, Beacham and Murray 1993, 1990). 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 Barnett and Spence (2011), 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.*, native 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, personal communication). The cues that trigger this phenomenon are unknown, but may be linked to environmental variation (Hayes *et al.* 2012, Satterthwaite *et al.* 2012, 2010, 2009, 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 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 a sandbar, 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 watersheds are similar those which have been investigated and documented in watersheds north of the SCCCS DPS.

Closely related to these life history strategies is steelhead use 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. Populations frequently differ in the timing and habitats they use while pursuing the general pattern of the anadromous life cycle; these differences may reflect the evolutionary response of populations to environmental opportunities, subject to a variety of biological constraints that are also a product of evolution.

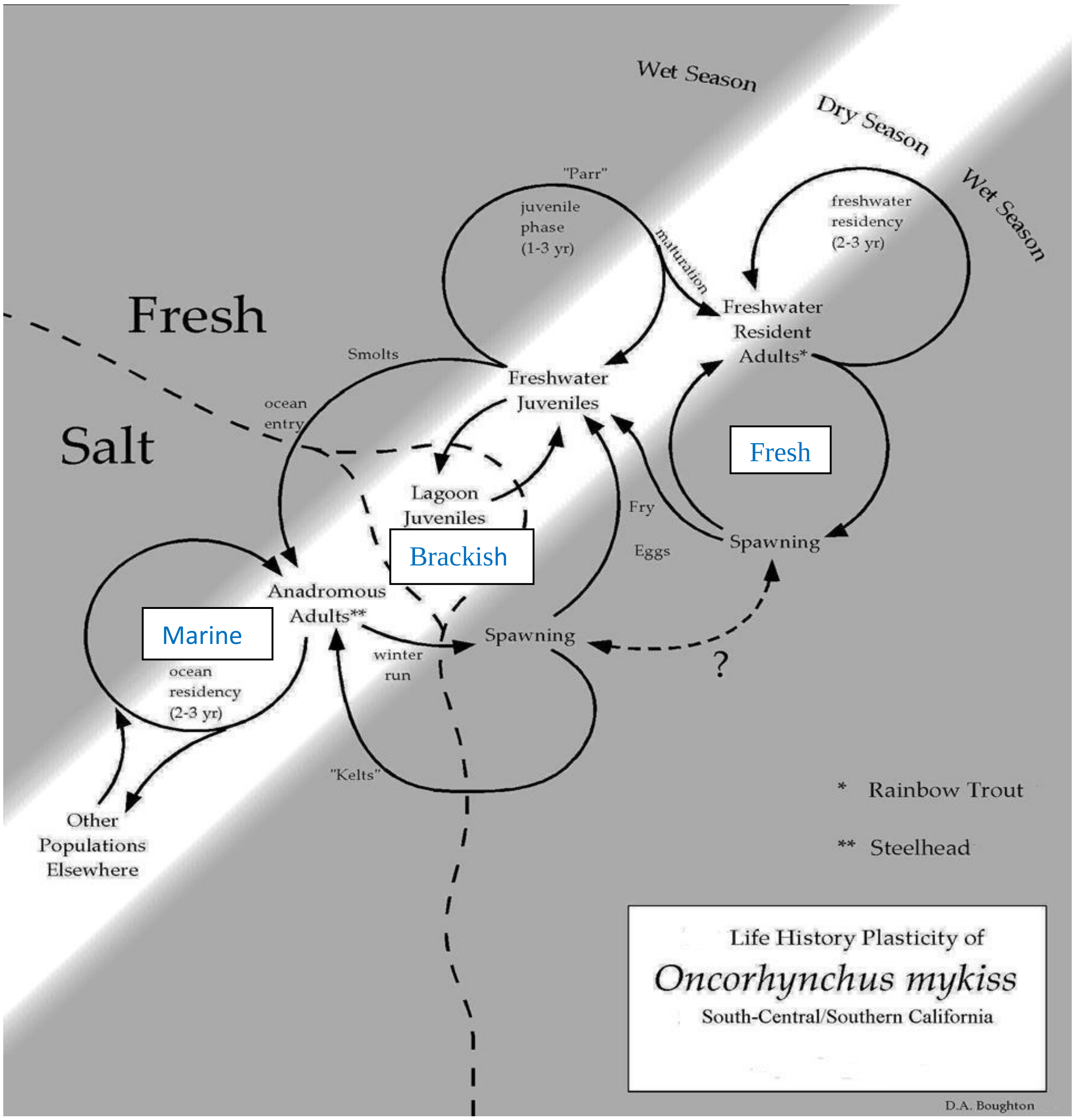

Figure 2-1. Summary of the various life history strategies exhibited by South-Central California Coast *O. mykiss* and the life stage specific terminology.

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*. 2012, 2011, 2008, M. Capelli, personal communication).

Figure 2-2. Adult Steelhead (*O. mykiss)* (*c.* 75 cm), Uvas Creek, Pajaro River, Santa Clara County, 2012.

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

Figure 2-4. Steelhead smolts (*c.* 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 reduced to critically low levels or extirpated, *e.g.*, in the Salinas River and in 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 native 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 39 watersheds in which steelhead were known to have occurred historically, virtually all were still occupied by either native resident *O. mykiss* or steelhead. One of these watersheds was considered unoccupied by steelhead because it was dry (Old Creek), and one was considered unoccupied because the survey found no current evidence of *O. mykiss* (Cayucos Creek). However, *O. mykiss* have subsequently been observed in both of these watersheds (M. Capelli, personal communication). (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. Reduced flow and fish-passage barriers (and therefore opportunities to migrate) appear to have played a large role in watershed-wide reductions or extirpations of SCCCS steelhead; however, in many cases, ancestors of sea-run steelhead continue to persist as native 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 of California steelhead 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 and water management practices, in combination with anthropogenic barriers to anadromy, have also contributed significantly to the reduction in steelhead distribution, particularly in mainstem habitats such as the Pajaro and Salinas Rivers in the Interior Coast Range BPG, and Pismo and Arroyo Grande Creeks in the Luis Obispo Terrace Biogeographic BPG.

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 (modified after Boughton *et al.* 2006).[1]

WATERSHED	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
Big 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	Negative obs.[3]
Old Creek	Dry[4]
Toro Creek	Yes
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, *CDFW*, 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*. Old Creek has an adfluvial population above of *O. mykiss* above Whale Rock Reservoir, and adult steelhead have been reported in Old Creek below Whale Rock reservoir as recently as 1998 (National Marine Fisheries Service 1998).
[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).*

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 four BPGs (Table 2-2). The division of steelhead populations into BPGs followed 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 the steelhead populations occurring in the individual watersheds. These differing physical characteristics have led to life history and genetic adaptations that enable the populations to persist in the widely varying and distinctive habitat regimes represented by the four 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, 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/DPS					
	Ecological Characteristics				
Population Group	**Migration Corridor**	**Migration reliability**[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	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, that is conditions prior to European settlement.
[2] The migration corridor of the mainstem crosses alluvial valleys, which renders the migration of adults, and especially smolts, problematic, particularly in dry years - while 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 east-slope populations.
[3] Except in the Santa Cruz Mountains of the Pajaro system, which are wetter.

In characterizing the historical, 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 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 adult steelhead 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 BPGs.

The separate watersheds comprising each BPG are generally considered as individual *O. mykiss* populations (*i.e.*, one watershed = one population of steelhead). Single BPGs encompass multiple watersheds and multiple *O. mykiss* populations. However, many watersheds in the 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 steelhead populations in these small watersheds is uncertain. The TRT proposed that at least three scenarios (not necessarily mutually exclusive) are plausible for explaining the persistence of these smaller populations (Boughton *et al.* 2007b):

1. Some of the populations in the coastal BPGs, though small, may be exceptionally stable and their continued presence may depend in part on steelhead dispersal between neighboring watersheds (an independent population supporting one or more dependent populations, thus forming a metapopulation). See Appendix A for a definition of an independent population.
2. Adult dispersal between neighboring watersheds within a coastal BPG may occur frequently 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 watersheds (*e.g.*, in the Big Sur Coast and San Luis Obispo Terrace BPGs) may depend on occasional or frequent adult dispersal pulses from populations in the larger inland watersheds (*e.g.*, Interior Coast Range or Carmel River BPGs).

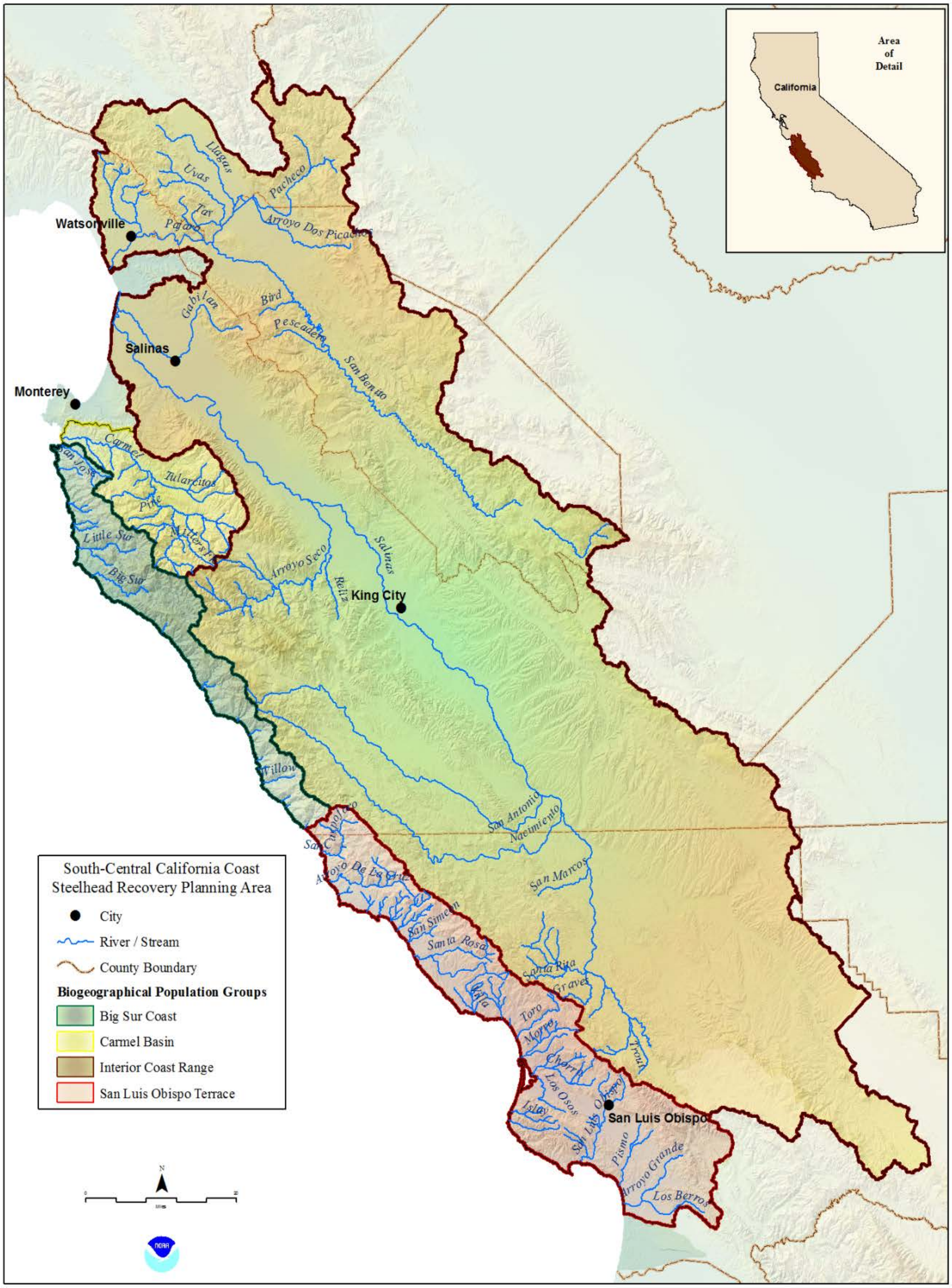

Figure 2-5. Biogeographic Population Groups (BPGs) in the South-Central California Coast Steelhead Recovery Planning Area (after Boughton *et al*. 2007b).

2.3 SPECIES ABUNDANCE

One of the recovery objectives in this recovery plan is to increase the abundance of steelhead, including the expression of all life history forms and strategies. The limited documentation on current abundance suggests the overall population in the SCCCS DPS is extremely small. Estimating the magnitude of the departure of the population from historical conditions is further hampered because the run size for most watersheds continues to be poorly characterized and major impacts leading to subsequent declines occurred prior to most modern fish investigations in the SCCCS DPS. The sporadic presence of steelhead in many watersheds in the SCCCS DPS further confounds assessment efforts.

The status of steelhead populations along the West Coast was assessed in 1996 by the 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 39 watersheds that historically supported anadromous runs, virtually all continue to be occupied by native *O. mykiss*, though most of the populations are at historically low levels.

As a follow-up West Coast Status review Good *et al*. (2005) reported three new significant pieces of information for the SCCCS DPS: 1) an updated time-series data set 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 historical range (see above); and 3) changes in harvest regulations for *O. mykiss*[1].

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.* 2011). However, this run-size estimate is based on information from only five major watersheds with steelhead (Pajaro, Salinas, Carmel, 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 not been estimated or recorded. Watersheds in the Big Sur Coast BPG have had relatively less disturbance than other BPGs and have most likely experienced less dramatic declines, while those within the San Luis Obispo Terrace BPG with a larger population and more extensive watershed developed, are likely to have experienced more dramatic declines (Boughton and Fish 2003, Boughton *et al.* 2005). 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 population 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 an average five-year adult count of only 16 adult spawners recorded at San Clemente Dam for these years (Busby *et al*. 1996, Good *et al*. 2005; see also, Monterey County Peninsula Water Management District 1991-2013, and Chapter 10, Carmel River Basin Biogeographic Population Group).

While -the BRT believed that general trends in the SCCCS DPS could be inferred from this

[1] Subsequent to these investigations additional historical records of *O. mykiss* have been identified (see Becker & Reining 2008).

early-1960 to early-1990 data, they also noted 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 years (Busby *et al*. 1996, Good *et al*. 2005).

Data collected from the Carmel River since the 2005, BRT status review indicates the abundance of anadromous *O. mykiss* spawners in the Carmel River has increased since the 1987-1992 drought, but that the average run-size has decreased since the early 1960s. 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 when no adult steelhead were detected (1988, 1989, and 1990). A pen rearing program was established for juvenile *O. mykiss* using facilities at the Monterey Bay Salmon and Trout Project 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 (see additional discussion in Chapter 10, Section 10.3). 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 dispersal rates, or ability of native 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.

Recent trends, based on 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 (2012-2013) counts for the Carmel River indicate 452 adults at the San Clemente Dam, and 204 adults at the Los Padres Dam, and reflect the effects of the most recent drought years 2007-2009 (Monterey Peninsula Water Management District 2012). Since the listing of South-Central California steelhead, there have been some increased efforts to periodically document 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, there are fish trapping and monitoring efforts on the Pajaro, lower Salinas River and the Carmel Rivers.

Finally, the BRT reported that the California Department of Fish and Wildlife (CDFW) 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, CDFW 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, there is currently take allowed of hatchery fish in some systems, including the Pajaro River.[2] While some of these areas are above impassable fish passage barriers, and currently do not provide accessible spawning and rearing habitat for anadromous *O. mykiss*, these upper watershed do have the potential to produce smolts from native resident *O. mykiss* that have the potential to contribute to the anadromous population if they can successively emigrate out of the watershed to the ocean.

[2] Angling regulations are subject to periodic modification. The CDFW's annual Sport Fishing Regulations should be consulted for current restrictions on angling for *O. mykiss* (both resident and anadromous).

However, the San Benito River flows on the east side of the Gabilan Range, and is considerably drier, with limited shading, and limited potential to provide over-summering habitat for rearing juvenile steelhead. Additionally, a few other creeks have summer catch-and-release regulations designed to minimize impacts to native *O. mykiss* from angling activities. While there is indirect evidence that such fishing pressure has resulted in minimal or no mortality to native *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 are sharply reduced. The three watersheds most likely exhibiting the largest annual anadromous runs (*i.e.*, Pajaro, Salinas, Carmel) have experienced declines in adult run size of 90 percent or more (Busby *et al*. 1996, Good *et al*. 2005, Williams *et al.* 2011). 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 inter-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 recent BRT assessment 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 and the threatened status has not changed (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 2008, Girman and Garza 2006, Nielsen 1999, 1994, Nielsen *et al.* 2001, 1997, 1994c). These studies have provided insights into the historical 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* collected from 11 tributaries (including several of the larger tributaries from both the upper and lower reaches) 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 than 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, a genetic reflection of their relative physical isolation.

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 above-barrier *O. mykiss* were more closely associated with below-barrier populations than to populations from other watersheds; also, that they were more closely related to the steelhead 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 – where 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 and return as adults, and thus have the potential to contribute to the persistence and therefore the viability of the anadromous population.

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

The major steelhead 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 support 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 the Northern District of the Los Padres National Forest. This forest is 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 conservation easements. 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, and in southern San Luis Obispo County (Kier Associates and National Marine Fisheries Service 2008a, 2008b, Hunt & Associates 2008a, 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 geological 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, Mayer *et al.* 1988).

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, Baldwin *et al.* 2012). 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, Davis and Borchert 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 Wildlife 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 U.S. National Forest are largely undeveloped, as are large portions of state parks, military bases, and reserves 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 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 to inland areas (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. Seasonally high, down slope winds during the early fall and winter are warm and dry and can exacerbate brush or forest fires, especially under drought conditions (Mastrandrea *et al*. 2009, Miller and Schlegel 2006a, 2006b, Haston and Michaelsen 1997, Philander 1990, Leipper 1994, Stine 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 very small and of extremely short duration, and does not contribute significantly to peak run-off. 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 geological 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 (Sloat and Osterback 2013, Atkinson *et al.* 2011, Boughton, *et al*. 2007a, Faber *et al.* 1989, Mount 1995, Jacobs *et al.* 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-covered ecosystems in the Sierra Nevada or the North Coast 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 watersheds draining directly westward into the ocean, and inland watersheds set back from the coast, often separated from it by extensive mountain ranges. The inland watersheds are relatively few, large, and have a continental climate whereas the coastal watersheds tend to be small, numerous and have 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 selective regimes/limiting factors on steelhead populations such as those in the Pajaro and Salinas Rivers. Coastal watersheds are often characterized by a "mountain-terrace" system, where a broad coastal terrace is backed by a steeper mountain range. These types of areas occur along the southern coast of San 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 suitable 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 watersheds of the SCCCS Recovery Planning Area.

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

Steelhead spend much of their life in the ocean, but must enter freshwater to reproduce. Dominant patterns in the region are one or two years in freshwater and one to two years in the ocean before returning to spawn in freshwater. Understanding the interaction between steelhead and their freshwater habitats is critical for effective steelhead recovery and management. Many of the naturally limiting factors (which are part of the natural selective regime) described in this section that affect the growth and survival of juvenile steelhead in their freshwater phase are exacerbated by anthropogenic modification of freshwater habitats and/or 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, where the lowland coastal plain portion of these watersheds present natural ecological constraints to fish passage. In the Pajaro River system, the lower mainstem and the lowland reaches of Llagas, Uvas, and Salsipuedes/Corralitos Creeks, are subject to significant streambed percolation into the aquifers, and reaches have a tendency to dry up in the spring, or even between storms in dry winters, with extended periods between storms. The Salinas River and the lower reaches of one of its major tributaries, the Arroyo Seco, also percolates large volumes of surface flow and goes seasonally dry, thus inhibiting fish passage of both adults and smolts. 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 parallel and serial linkages:

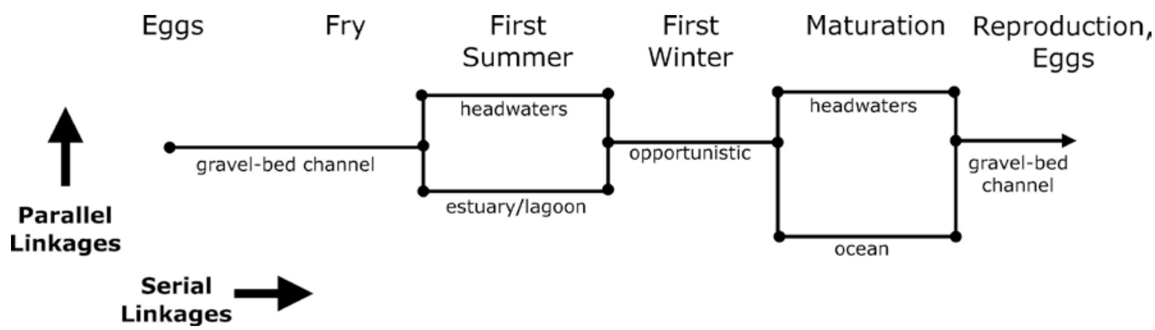

Figure 2-6. South-Central California Coast *O. mykiss* Life Cycle Habitat Linkages (Schwing *et al.* 2010, after Boughton).

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 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 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° Celsius, a warming or an increase in week-scale variability of temperature can increase the growth rate of salmonids if food is abundant. However, warmer temperatures also increase metabolic demand and can reduce growth if food is limiting (Sloat and Osterback 2013, 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 (unimpaired conditions). The hot, rain-free summers in the SCCC DPS require that juvenile *O. mykiss* occupy stream reaches which remain wetted and where temperatures do not exceed their thermal tolerance. Regionally, there are two alternative mechanisms that create 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 watersheds these two mechanisms merge geographically, whereas in inland watersheds the operation of these mechanisms may be separated by a long stretch of dry or warm channel that creates a summer-long barrier to movement. Numerous tributaries draining various mountain ranges provide a high level of redundancy of rearing refugia in the montane thermal refugia.

Probably as important as air temperature in maintaining cool water temperatures during the summer is reduced solar incidence which 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, particularly in estuaries (Bogan *et al*. 2004, 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 water 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 presence of a properly functioning riparian canopy.

Mountain refuges appear more vulnerable than coastal refuges to thermal increases in water temperature during the summer (Snyder *et al*. 2002), where the latter are buffered by a maritime climate. An alteration of fire regime, flood regime, and/or sediment may eliminate a properly functioning 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 portions of the watershed that fall within a rainshadow or in reaches with deep alluvium or already impaired flows. 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 the SCCCS DPS (see for example, Shapovalov 1944).

Groundwater inputs and heat-exchange with the channel-bed can buffer daily and annual temperature fluctuations in a stream (Hannah *et al*. 2004, Tague *et al*. 2009, 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, that is negligible heat increase or loss (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, but would 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 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 of large coastal rivers such as the Salinas and Pajaro, many of these coastal streams also benefit thermally from the temperature lapse rate in the coastal mountains, as well as receiving orographic precipitation in the wintertime - the converse of the streams in the rain shadow of inland areas. The coastal area is probably significantly more resilient to the consequences of climate change (*e.g.*, ambient air and water temperatures) than inland areas because of the moderating effects of the marine environment, and highly productive per unit of habitat. However, it is a very narrow band and so its effect to overall productivity of the SCCCS DPS is limited.

Each watershed occupied by SCCC steelhead 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 watershed. Juvenile steelhead over-summer in these lagoons, where they often grow so rapidly that they can undergo smoltification at age one 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 life history component of *O. mykiss*. In contrast, juveniles over-summering in some montane thermal refugia often display very little or no growth during the summer (Sogard *et al*. 2012, 2009, Hayes *et al.* 2008, Boughton *et al*. 2007a, Bond 2006) .

Fall and Winter Rearing (unimpaired conditions). Steelhead rearing ecology during the fall and winter is less documented, but is likely less constrained than earlier life phases (incubation, hatching, and emergence) or later over-summering phases. Baseflows rebound in some 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 percolates into the ground, and larger interior watersheds may require considerably more rain to re-initiate surface flows. 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 in the SCCCS DPS, 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, California, indicate most *O. mykiss* become smolts and migrate to the ocean at age two or three, but a small proportion smolt at age one (Hayes *et al*. 2011, Sogard *et al*. 2009, Hayes *et al*. 2008, Shapovalov and Taft 1954; see also Atkinson 2010). Since larger size at ocean entry greatly increases ocean survival (Hayes *et al*. 2008, Bond 2006, Ward *et al*. 1989), smolting at age one is probably only a viable strategy for fish that have achieved 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 local adaptations, including a “decision” as to whether to smolt versus maturing in freshwater. Local adaptation is likely dominated by a tradeoff between ocean mortality and greater fecundity that fish achieve 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 native 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 limits 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, Bêche *et al.* 2009). Additionally, 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 (for estuary moth opening patterns, see 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 native resident *O. mykiss* 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 potential 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 two or three 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 constraint to survival. 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 may be more restricted to the parts of the watershed that provide well-shaded perennial pools of sufficient depth. Because of the geology and topography, these appear to be concentrated in headwater streams well-fed by orographic precipitation, where baseflows are stable, 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 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, 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 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 each of the factors which contributed to the species' listing be addressed in the recovery actions identified in the recovery plan.

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 identified the factors adversely 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. While some of these factors have been ameliorated to some degree in a number of watersheds they continue to persist throughout the SCCCS DPS (and the larger Recovery Planning Ares), and thus continue to threatened the existence of the species.

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

Steelhead in the SCCCS DPS have declined 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 systemic threats to steelhead habitat, dams and other water control 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 (including passive and active recreational activities and related facilities such as reservoirs and trails) 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 sediment 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. (Kier Associates and National Marine Fisheries 2008a and 2008b, Carmel River Coalition 2007, Smith *et al*. 2004, Gilchrist *et al*. 1997, Ferren *et al.* 1995, Cadmus Group 1992, Smith 1976, Gerdes *et al*. 1974). The condition of these remaining wetland habitats is significantly degraded, with many wetland areas at continued risk of loss or further degradation. Although many historically harmful practices have been halted, the historical damage remains largely unaddressed, 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 winter and summer low flow periods when fish are concentrated in freshwater habitats), the impacts of recreational fishing 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 in some waters under the CDFW's angling regulations, though the CDFW imposes angling restrictions within the anadromous waters of the SCCCS DPS to minimize impacts to native *O. mykiss* from angling activities (*e.g.,* restrictions on the length of the winter angling season; limiting angling to the lower reaches of most anadromous rivers and streams; angling gear limitations , including barbless hooks; and catch and release only of steelhead), though the take of hatchery fish (including hatchery reared steelhead) is allowed in anadromous waters. There is generally no summer trout angling season for the anadromous waters of the SCCCS DPS. The exceptions to these restrictions include San Benito River within the Pajaro River watershed, the upper reaches of the Arroyo Seco and the Nacimiento River, within the Salinas River watershed, the Carmel River above Los Padres Dam, and the Big Sur River and Salmon Creek, above natural barriers to upstream fish migration).[1] All anglers must possess a nontransferable Steelhead Fishing Report and Restoration Card issued by the CDFW in their possession while fishing for steelhead trout in anadromous waters (California Department of Fish and Wildlife 2013).

While there is indirect evidence that such fishing pressure has resulted in minimal or no significantly mortality to native *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* and the mortality resulting from angling opportunities is not quantitatively known. No Fishery Management and Evaluation Plan (FMEP) has been approved by NMFS for the SCCCS DPS (California Department of Fish and Wildlife 2001).

[1] Angling regulations are subject to periodic modification. The CDFW's annual Sport Fishing Regulations should be consulted for current restrictions on angling for *O. mykiss* (both resident and anadromous.

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 recreational angling pressure has resulted in minimal or no significant mortality to *O. mykiss*, poaching remains a potential form of unauthorized take of South-Central California Coast steelhead, particularly in watersheds that traverse areas with concentrated human populations such as the Pajaro River (and its tributaries), and the Carmel River.

Fish Trap – Lower Pajaro River – 2013 (Courtesy Monterey County Sheriff Department)

NMFS had previously concluded, based on the available information, that recreational harvest is a limiting factor for South-Central California Coast steelhead, though the significance of this factor is uncertain (Good *et al.* 2005, Busby *et al.* 1996, National Marine Fisheries Service 1996a).

The completion of an FMEP for the SCCCS DPS provides one mechanism for addressing this issue and informing fishery managers' decisions on annual angling regulations (California Department of Fish and Wildlife 2001, Gutherie 1990).

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 (often in association with the construction of dams and associated reservoirs that act a refugia for non-native warm water species). 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).

Adult *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 *et al*. 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 one U.S. National Forest within the SCCCS Recovery Planning Area (Los Padres National Forest, Monterey and Santa Lucia Ranger Districts); 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 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, has 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 401 programs.

Additionally, the USACE does not regulate most agricultural, forestry, or ranching 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 SCCCS Recovery Planning Area, 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.

Finally, prior to the listing of SCCCS DPS, the NMFS exercised only a limited role in the protection of the listed species. While this role has expanded, the enforcement of the protections afforded by Section 9 of the ESA is constrained by limited staffing and remains a substantial challenge.

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 California Fish and Wildlife 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 CDFW 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 CDFW provides protection of riparian and aquatic habitats. Inadequate funding, staffing levels, training and administrative support have led to inconsistent implementation of this critical 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), the state-wide organization, CalTrout, and the national organization, Trout Unlimited; 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, existing funding is limited, and dedicated funds for its implementation have not been identified and secured.

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

This factor encompasses two specific threats to the species identified at the time of listing: 1) environmental variability and 2) stocking programs. As with the other listing factors, these threats have continued to play a role in the status the SCCCS DPS. More recent information regarding environmental variability, including the effects of climate change on ocean and freshwater, and increases in the occurrence and severity of wildfire, indicate the threat from "environmental variability" is expected to increase.

3.5.1 Environmental Variability

Natural environmental variability in a Mediterranean climate both masks and exacerbates problems associated with degraded and altered riverine and estuarine habitats. Assessing the role of natural variability in the decline of anadromous and non-anadromous *O. mykiss* requires long-term comparative investigations of unimpaired and impaired watersheds. Floods and persistent drought conditions, however, have periodically reduced naturally limited spawning, rearing, and migration habitats (*e.g.*, by reducing flows, spawning-gravel recruitment, vegetative cover). Long long-term climate changes may exacerbate the effects of these periodic conditions as well as complicate long-term comparative studies in the SCCCS Recovery Planning Area.

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). The current and future threat to species recovery from environmental variation is discussed in more detail in Chapters 4 and Current DPS-Level Threats Assessment, and 5, South-Central California Coast Steelhead and Climate Change.

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 River and various tributaries (*e.g.*, Corralitos, Browns Valley, Uvas Creeks) as well as in the Arroyo Seco in the early 1990s.

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 an ocean net pen rearing operation for Chinook salmon (*Oncorhynchus tshawytscha*) operated by Central Coast Salmon Enhancement from 1984-2007 (in later years this was operated as a cooperative facility with the CDFW). The pens were located in San Luis Bay and returning adults were occasionally observed in adjacent San Luis Obispo Creek.

CDFW maintains a stocking program of hatchery-derived non-anadromous *O. mykiss* to support put-and-take fisheries. These stockings are generally conducted in non-anadromous waters (*i.e*., areas above natural barriers and dams), though fish may enter anadromous waters during spillage at dams. Until recently, CDFW 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). Since the issuance of the CDFW's Hatchery and Stocking Program EIR/EIS, the CDFW has limited fish stocking of hatchery reared *O. mykiss* to triploid rainbow trout, and to non-anadromous waters and waters where fish cannot emigrate downstream into anadromous waters (California Department of Fish and Wildlife and U.S. Fish and Wildlife Service 2010). 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 Wildlife 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 Wildlife and National Marine Fisheries Service 2001). Increased restrictions on recreational angling have been prompted by increasing human pressures on the indigenous fishery resources, but are not intended to address the underlying causes of population declines or maintain natural ecosystem functions (California Department of Fish and Wildlife 2000, Butler and Borgeson 1965).

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). Genetic investigations of SCCCS steelhead have not detected any substantial interbreeding of native *O. mykiss* 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 SCCCS 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 Wildlife and U.S. Fish and Wildlife Service 2010). Collection of native steelhead for hatchery broodstock purposes has the potential to harm small or dwindling natural populations. However, artificial propagation may play an important role in steelhead recovery through preservation of individuals representing genetic resources which would otherwise be lost as a result of local extirpations (see Chapter 8, Summary of DPS-Wide Recovery Actions, Section 8.3 Conservation Hatcheries).

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 threatened 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 in the threats assessment conducted for watersheds within each BPG. The threat sources with a "very high" or "high" severity ranking were dams and surface water diversions, wildfires, and groundwater extraction. The adverse effects of dam and surface water diversions are particularly significant because they impact steelhead by, blocking migration routes to spawning and rearing habitats, and altering natural flow regimes essential for maintaining these habitats.

While wildfires are a natural occurrence, and an important part of the life cycle of the chaparral plant community that dominates a significant portion of the SCCCS Recovery Planning Area, they ranked as a very high threat throughout the SCCCS DPS. Consequently, their management, and role in determining the distribution of watersheds to be restored is fundamental to the over-all recovery strategy of the Recovery Plan (see further discussion in Chapter 6, Criteria D-2- Redundancy and Geographic Separation).

Urban development, levees and channelization, and other passage barriers also adversely affect a large percentage of steelhead watersheds in the SCCCS Recovery Planning Area and were therefore ranked high in the threats assessment for significant portions of the SCCCS DPS.

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

Finally, while not captured explicitly in The Nature Conservancy's threats assessment process, the impacts of environmental variability, including projected changes in precipitation patterns and the consequences of fluctuations in ocean conditions will likely play a significant role in the persistence and recovery of the SCCCS DPS. The basic recovery strategy, to restore and protect a wide variety of steelhead habitats (including refugia habitats) throughout the SCCCS Recovery Planning Area is intended to address the this largely unpredictable threat to the recovery and persistence of the SCCCS DPS; this issue is addressed in Section 4.1 and 4.2.7 below, 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 (Chapters 9-12).

4.1 THREATS ASSESSMENT PROCESS

NMFS assessed current and expected future threats to steelhead persistence and recovery in key watersheds identified by the TRT and NMFS staff. This assessment used The Nature Conservancy's Conservation Action Planning (CAP) framework (The Nature Conservancy 2007, 2000). 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 allowed NMFS to organize the best available information (and professional judgment when no other information was available) on the threats impacting SCCC steelhead. Information was entered into electronic workbooks 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 iterative and 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 evaluated in the CAP framework is located in Appendix D.

In addition to the CAP threats assessment, NMFS evaluated the best available information regarding impacts of predicted shifts in climate and the marine environment and the impacts of these shifts on the ability of steelhead to recover. These two threats were not easily addressed in the CAP workbooks and so are not explicitly 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 identifying an overall recovery strategy for the species and particular recovery actions. Steelhead will be able to persist through changing environmental conditions with recovery of well-distributed viable populations across the SCCCS Recovery Planning Area. Well distributed and viable population will support a variety different life stages and life history strategies which will add resiliency to the SCCCS DPS. Recovery actions addressing climate and marine conditions are embedded within recovery actions designed to achieve these objectives; some of the most significant for the SCCCS DPS are the restoration and protection of flows, ensuring access to spawning and rearing habitat, and restoration of riparian and estuarine habitats providing refugia during extreme droughts or other weather events that can degrade steelhead habitat.

4.2 CURRENT DPS-WIDE THREATS ASSESSMENT SUMMARY

The following discussion presents information on current and future threats impacting steelhead in the SCCCS DPS. The discussion is organized around a set of threat sources identified for each BPG in Chapters 9-12 and associated appendices. The information presented in this chapter is a summary of threats across the SCCCS Recovery Planning Area.

The current conditions of 27 major watersheds within the SCCCS 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. Percentage of watershed within the BPGs with High or Very High threat sources.

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	50%	0%	29%	33%
Mining	50%	0%	0%	0%

** Percentages were 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, and upper Salinas Dams), Carmel River (San Clemente and Los Padres Dams, other passage barriers), and Pajaro River and tributaries (groundwater extraction, Uvas, Chesbro, and Pacheco Dams, flood control, and diversions in the lower reaches) in the Interior Coast Range BPG. A widespread trend in the SCCCS Recovery Planning Area is severe to very severe degradation of habitat conditions along the mainstem of many 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, Verkaik *et al.* 2013, Keeley *et al.* 2012, 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 Wildlife 2012a, California Conservation Corps 2005, California Coastal Conservancy 2004, California Department of Water Resources 1988). Loss of surface flows through the operation of dams or surface water diversions along the mainstem of the river adversely affect the productivity of important downstream mainstem habitats, and upstream tributaries otherwise providing spawning and rearing habitats for anadromous steelhead. Re-establishing surface flows and/or maintaining hydrologic connections and physical access between the ocean and upper watersheds would expand access to historically important spawning and rearing habitats. Restoring hydrologic connection and physical access is essential to recovery of the SCCCS DPS. Such a strategy 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 lead to the introduction 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 (Petts and Gurnell 2013, Muhlfeld *et al.* 20011a, 2011b, Brown and Bauer 2009, Johnson *et al.* 2008, Keefer *et al*. 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, Ligon *et al.* 1995, National Marine Fisheries Service 1996a, Roberts and White 1992).

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

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 watersheds. 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 were extensively developed for agriculture, which typically occurs on 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 bases, *etc.*) can be extensive, these public lands are typically concentrated in the upper watersheds leaving the middle and lower watersheds subject to private development (Cooper *et al.* 2013, 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 a 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, Newcombe and Jensen 1996, 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, and bullhead catfish, are often stocked into both non-anadromous and anadromous waters (including artificial reservoirs) by public and private entities. Additionally, other non-native species such as striped bass have spread into some of the watersheds of the SCCCS Recovery Planning Area (*e.g.*, Pajaro, Salinas, and Carmel Rivers) from other areas. While these stocking efforts have provided seasonal fishing opportunities, the impacts of these no-native fishes 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 SCCCS 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 in the past have distributed non-native steelhead stocks in many coastal rivers and streams in California (California Department of Fish and Wildlife and U.S. Fish and Wildlife Service 2010). Because of problems associated with the practice of transplanting non-native steelhead stocks, CDFW developed its Salmon and Steelhead Stock Management Policy. This policy recognizes 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 CDFW 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, CDFW 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 Wildlife and U.S. Fish and Wildlife Service 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 are 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 such as highways and railroads (primarily in the more extensively developed northern and southern portions of the SCCCS Recovery Planning Area). Gleason *et al*. (2011), Grossinger *et al.* (2011, 2008), 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 been substantially reduced as a result of: (a) loss of shallow-water habitats such as tidal channels, (b) degradation of water quality through both point and non-point waste discharges, and (c) artificial breaching of the seasonal sandbar at the estuaries mouth which can reduce and degrade steelhead rearing habitat by reducing water depths and the surface area of estuarine 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 Creeks) the most physically intact, though they are impaired by reduced freshwater inflows as well as 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 key 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 California Coast Steelhead Recovery Planning Area, grouped 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	< 1
	Chorro and Los Osos Creeks	83
	San Luis Obispo Creek	60
	Pismo Creek	30
	Arroyo Grande Creek	20

[1] Note: these percentages are of based on a comparison of a variety of sources, which used different methods for defining wetland habitats, and differing methods of calculating their areal extent. Nonetheless, these data provide an approximate measure of *relative* estuarine habitat loss. Adapted from Kier Associates and National Marine Fisheries Service (2008a, 2008b).

4.2.6 Marine Environment Threats

Adult steelhead spend the majority of their life 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 relatively 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 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 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 climate of the SCCCS Recovery Planning Area is classified as Mediterranean. Mediterranean climates are characterized by two distinct annual seasons, with a high degree of inter-annual and decadal variability: a long rainless season extending from June through September (with small amounts of rain in May and October) and a brief rainy season from November through April. Rainfall is typically brief, and associated with 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 Niño-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 are significantly influenced 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 abundant and appropriately sized food sources to support the large numbers of maturing fish emigrating from coastal watersheds to the North Pacific Ocean (Quinn 2005, Moyle 2002). Both freshwater and marine environments are affected by weather and climatic conditions varying 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 (Schwing *et al.* 2010).

4.2.8 Pesticide Use

The extensive use of pesticides for commercial agricultural purposes, as well as industrial and home applications, and their effects on anadromous salmonids has become an increasing concern (Baldwin *et al.* 2010, Macneale *et al.* 2010) for salmonid conservation. 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 adverse 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 Area (*e.g.*, Pajaro, Salinas, Santa Rosa, and Arroyo Grande) are 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. See Appendix E for general guidance on best management practices in the application of pesticides.

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 human response to this change will likely be a major theme in the 21st century (Intergovernmental Panel on Climate Change 2012).

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 SCCCS steelhead have evolved a suite of effective adaptations to a highly variable environment (including multiple paths for completing their life cycle), the rapid rate of projected climate change presents a significant challenge to their long-term 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, 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 2014a, 2014b, 2013, 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 heightened for Pacific salmonids due to their dependence on 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 likely not as profound as other regions of California. For example; (a) in the Central Valley, anadromous fish populations dependent on snowmelt-fed riverine habitats may undergo a conversion to rain-fed habitats, or (b) along the central and north coastal areas where Coho salmon (*O. kisutch*) populations, which have a fixed three year 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) to which South-Central Coast populations of steelhead appear to have evolved a flexible, opportunistic survival strategy. An important factor for coastal steelhead populations is the continuing role of the ocean in moderating coastal climates due to its high heat capacity. Coastal steelhead populations at the southern extent of the SCCCS DPS appear to have a more predictable future despite changing climate condition. However, steelhead in the Interior BPG will likely be more vulnerable to climatic changes as a result of increased ambient temperatures and less predictable rainfall patterns (Boughton 2010a). The human response to projected (and actual) climate change introduces an additional uncertainty in the recovery of the SCCCS DPS (Intergovernmental Panel on Climate Change 2012).

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 modeling assumptions and emissions scenarios (Hayhoe *et al*. 2004). Climate models appear to make a median prediction of about a 10% loss of precipitation statewide by 2100, under a low emissions scenario (Cayan *et al*.

2009, 2006). 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° Celsius (C) for sensitive climate models, and 1° C for the less sensitive model (Shaw *et al.* 2009). The statewide precipitation response is relatively small, ±4 centimeters (cm) 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, Milhous *et al.* 2003). 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 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 California watersheds, and the possibility of large decreases in mean precipitation (Shaw *et al.* 2009, Cayan *et al.* 2008a, Milhous *et al.* 2003).

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). Changes projected under the middle-upper emissions scenario are the prelude for faster changes in the 22nd Century, with no prognosis for stabilizing greenhouse gas concentrations and climate.

Regional climate projections for the South-Central California watersheds suggest a future of longer, hotter summers, with a potentially higher incidence of fog along the immediate coast. These projections also suggest more extreme heat waves and droughts, but with perhaps more intense precipitation events in some areas (Karl *et al.* 2009, 2008, 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 smolts 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 to the Pacific Ocean (Jacobs *et al.* 2011, Maurer *et al.* 2006, Quinn 2005).

Rivers and riparian areas (and associated wetland areas) make up less than one percent of the landscape in regions such as South-Central California. These highly productive ecosystems are embedded within upland systems with much lower productivity (Warner and Hendrix 1984). 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 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 contributes 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) project a decrease in vegetative cover which 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 (Mantua *et al.* 2010). Increased stream temperatures will have direct and indirect adverse impacts on juvenile *O. mykiss*. These impacts include subjecting the species to increased physiological stress, and altering the aquatic environment through modifications such as reduced dissolved oxygen levels or increased growth of algae and rooted aquatic vegetation that can increase the diurnal bio-oxygen demand in a river system.

Elevated stream temperatures can favor the proliferation of non-native warm water species that can compete for living space, food, 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 *et al.* 2003, 1999, Mohseni and Stefan 1999, Eaton and Schaller 1996).

Wildland Fire. Chaparral is the predominant vegetation type within the SCCCS Recovery Planning Area. Wildfires are a natural phenomenon essential for the periodic renewal of chaparral plant communities (Keeley *et al*. 2012, Van de Water 2011, Bendix and Cowell 2010a, 2010b, Sugihara *et al.* 2006, Davis and Borchert 2006). 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, Loaiciga *et al.* 2001).

Hot, dry winds (known locally as "Diablo Winds) occur during the summer in the upper Salinas Valley 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 spread fires rapidly, sometimes burning many square miles of chaparral and shrub vegetation per day (Keeley *et al.* 2012, Davis and Borchert 2006, Keeley 2006, Keeley *et al.* 1999, Ryan and Burch 1992,). 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 (Verkaik *et al.* 2012, Capelli 2009, Cooper 2009, National Marine Fisheries Service 2008b, Backer *et al.* 2004, Finger 1997).

5.1.2 Marine Environment

Steelhead adults spend the most of their lives in the marine environment, entering freshwater habitats for brief periods to reproduce. While steelhead are subjected to the same basic ocean 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. Nonetheless, 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 (see Beamish *et al.* 2010 for a comprehensive bibliography of climate impacts on Pacific salmon). .

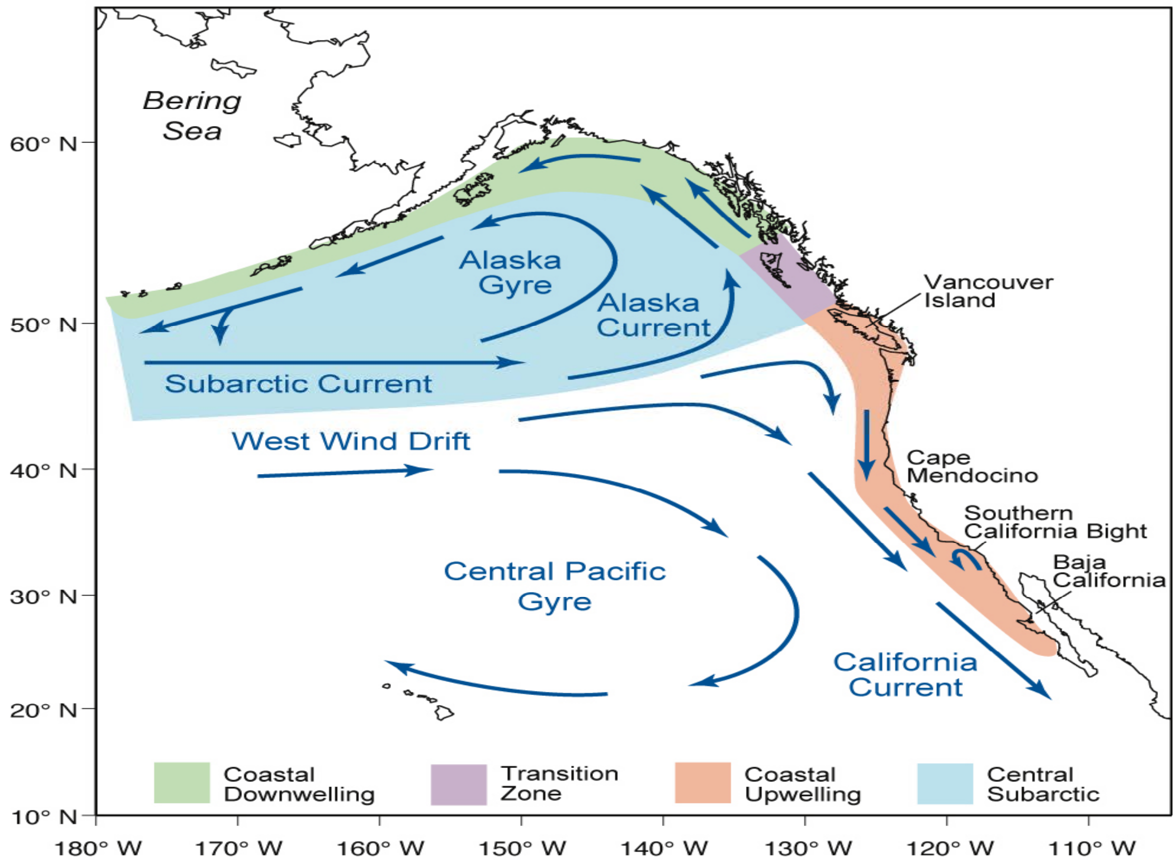

Figure 5-1. Principal Ocean Currents in the North-East Pacific Ocean Affecting Coastal Waters of California (J. A. Barth, Oregon State University

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 2011, Mantua *et al.* 1997). Due to the paucity 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 and others predict 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.* 2011, Mastrandrea *et al.* 2009, Karl *et al*. 2008, Bell and Sloan 2006, Benestad 2006, Bell *et al.* 2004, Trenberth 1999) which will result in decreased ocean survival.

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 patterns and intensity 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 making the likely response of SCCCS steelhead to these climate driven changes more uncertain (Boughton 2010a, Boughton *et al.* 2006, 2007b).

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 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 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 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.

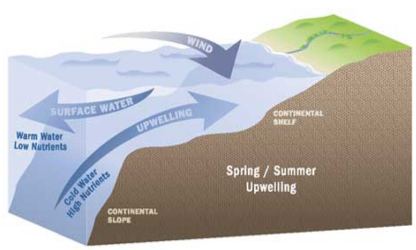

Figure 5-2 Seasonal Coastal Upwelling Pattern Along the California Coast (Courtesy NOAA)

If this occurs phytoplankton blooms may not be as intense, which may impact organisms up the food chain including salmonids (Roemmich and McGowan, 1995). Given a future warmer climate, the upper ocean 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 (Hazen *et al.* 2012, Grebmeier 2012, Shoji *et al.* 2011, Lindley *et al.* 2007, Swartzman and Hickey 2003).

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 pronounced latitudinal differences in 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 entering the California Current from the north and offshore can exert some control over the primary phytoplankton and zooplankton species in the current. The occurrence of low returns of Pacific 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 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. Similar, PDO conditions affect steelhead populations with in the South-Central Coast watersheds (Mantua and Hare 2002,

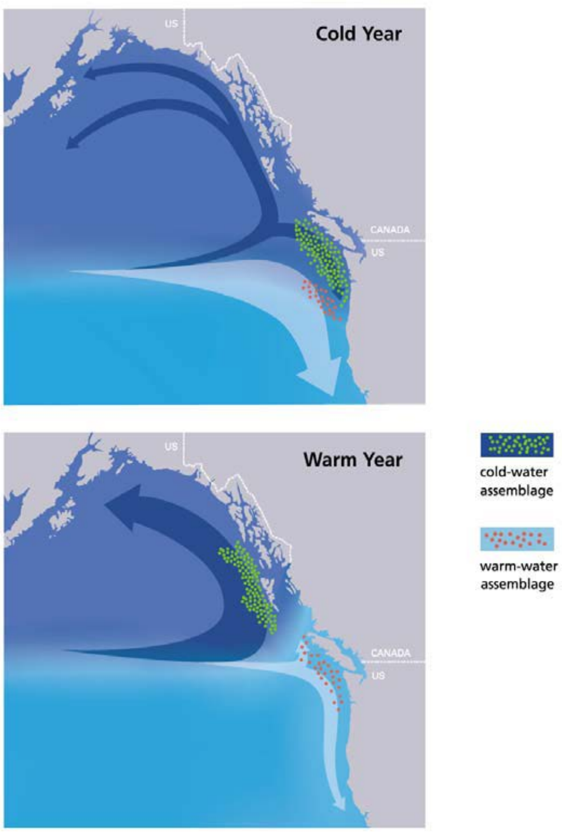

Figure 5-3. Shift in Cold and Warm-Water Faunal Assembles During Pacific Decadal Oscillations and El Niño/La Niña/Southern Oscillations (Osgood 2008)

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 generally 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 where juveniles rear a portion of the year in the estuary of natal rivers or streams. Studies in small coastal estuaries/lagoons seasonally closed off from the ocean by sand bars have shown these habitats can be productive rearing areas for *O. mykiss*. Juveniles rearing in lagoons can grow 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 entering the ocean at a larger size exhibit greater survival rates, and are disproportionately represented in the adult spawning population (Hayes *et al.* 2008, Bond 2006).

Changes in sea level, which have the potential to adversely affect important estuarine habitats, have already been reported and are expected to continue. Researchers have projected by 2035-2064, global sea level rise will range between 6 and 32 cm above 1990 levels, regardless of emission scenarios. Between 2070-2100, the projected range of sea level rise varies between 11-54 cm to 17-72 cm depending on the emission scenario (Cayan *et al*. 2009, 2008b, Pilkey and Young 2009, Raper and Braithwaite, 2006). These more recent estimates suggests a larger rise in sea level than previously projected by Hayhoe *et al*. 2004 and Ewing 1989. A projected 1 meter (m) rise in sea level could 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 estuaries confined by surrounding development because their inland boundaries are prevented from naturally adjusting in response to ocean 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 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 (Feely *et al.* 2008, 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. 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 sockeye (*Oncorhynchus nerka*), pink (*Oncorhynchus gorbuscha*), and chum salmon (*Oncorhynchus keta*, a reduction in pteropods can adversely affect the marine growth of these species. One bioenergetics/food web model predicts 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 their marine diet. 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 adult salmonids to modify their diets accordingly (Schwing *et al*. 2010). The long-term consequences of ocean acidification on marine ecosystems are poorly understood (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 steelhead are even more uncertain (Nielsen and Ruggerone 2009, Myers *et al*. 2000, 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 it is rare 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 the various anadromous salmonids. To understand the implications of climate change for salmonids, we established a conceptual framework to organize this complexity (Schwing *et al.* 2010). The framework is reflected in the viability criteria and recovery strategy described in Chapters 6, and 7, which is based on the highly variable climatic conditions characteristic of the SCCCS Recovery Planning Area, and should provide guidance in the adaptive management of steelhead as the climate continues to change. The criteria and recovery strategy emphasize the need for steelhead population and habitat redundancy and diversity to buffer the SCCCS DPS against current and future extreme weather conditions and associated population fluctuations.

The framework used here organizes complexity into four broad spheres: 1) the multiple life history pathways open to salmonids as a function of their adaptations and ecological tolerances; 2) the environmental opportunities 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 allowed a systematic treatment of each life stage, each habitat used by each life stage, and each way 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 steelhead populations will respond 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 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 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 - particularly 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.

5.2.4 Freshwater 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; see also, Rivaes *et al.* 2013). 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 and they exhibit a dynamism 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 refugia, is considered 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 provide little resilience to them because they 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 in a headwater stream (via the temperature lapse rate), moist shaded conditions (transpiration), or in a coastal lagoon (via proximity to the ocean heat sink). Sparsely shaded higher elevation habitats can also produce warmer water conditions; conversely, lower, shaded habitats can produce cooler conditions. For example, large portions of coastal lagoons can be unshaded, and unless subject to persistent fog, can be warm rather than provide a cool refugia. Wind mixing of the water column (accompanied by elimination of salinity stratification) which allows the lagoon to cool at night, can be a critical factor (Smith 1990).

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 fog movement. Alternative pathways are less likely than redundant pathways to exhibit a consistent response pattern 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 addresses 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 habitats and migration corridors connecting them are suitable, and whether fish are at a suitable stage of development to move between habitats.

Rapidly changing climate may alter such opportunities by creating critical mismatches in development and habitat conditions in areas where 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 early spring when flows are high. During these periods of elevated instream flow, adult steelhead migrate to high elevation habitats that are often inaccessible later in the season when flows are lower. The timing of these flows depends on precipitation. Following successful spawning and incubation fry emerge from their redd and enter the water column approximately two months later (emergence time is strongly influenced by water temperature). Growth and development of young fish to the smolt stage is also influenced by water temperature. Smolts typically enter the ocean from late winter to late spring, when ocean 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 (Thorson *et al*. 2013, 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 predictable, the response of ecosystems and the consequent future conditions of steelhead habitats are less predictable. The inherent difficultly in predicting overall habitat response to climatic changes suggests adoption of a precautionary principle whereby protecting key biological parameters will be necessary to ensure long-term resiliency of the population. This strategy will 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, also, Kingsford 2011):

- ❑ 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 evolutionary potential 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) by restoring a natural diversity of habitat types that support a wide diversity of life history expressions; and

- Maintain the capacity to detect and respond sustainably to ecosystem changes as they occur.

The viability criteria outlined in Chapter 6, and the recovery strategy identified in Chapter 7, Steelhead Recovery Strategy reflects these core principles, and provides a basic strategy for dealing with the current variable climate regime, as well as projected future climate regimes.

Because of the potential climate changes and the uncertainties regarding the physical habitats and corresponding biological responses, to these changes, there will likely be a need to extend the analysis of the TRT. The following climate change related questions were identified by the TRT:

- How will climate trends alter the wildfire regime which in turn will alter sediment delivery and hydrologic processes affecting 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 water 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 flow 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 is *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 ensure a sustainable South-Central California Coast steelhead sport fishery through the restoration of viable steelhead populations across the SCCCS DPS.*

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. These efforts will target conservation of the full range of 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). Targeting the full range of life history forms will allow these fish to successfully use a wide variety of habitats which will help them overcome the natural challenges of a highly variable physical and biological environment into the future.

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 steelhead recovery.

Steelhead in South-Central California occupy highly variable 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. Existing threats constrain the species' current distribution to small, disjunct portions of its historical range and preclude steelhead from expressing their full range of life history strategies in response to naturally varying habitat conditions. To recover, the SCCCS DPS requires substantially higher numbers of returning adults, successful spawning, successful juvenile rearing in freshwater and estuarine environments, and emigration of juveniles and adults to the ocean. To achieve these goals, it is essential to preserve and restore the species' existing freshwater habitat, as well as restore its access to historically important spawning and rearing habitats throughout the SCCCS 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 were 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 steelhead abundance 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 a species has "recovered" and can 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, must be met. These criteria are related to the condition of the species and the status of identified threats at the time of listing. In the case of delisting the threatened 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 principal 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 are 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 these criteria have not been established quantitatively because additional research is needed to define or refine them. Due to the lack of quantifiable information, one of the six recovery objectives for the SCCCS DPS focuses on research and monitoring. Research and monitoring is needed to refine delisting criteria and provide a means to evaluate whether steelhead populations are responding to recovery actions. Given the species' condition and the severity of the threats in the SCCC DPS, it is clear significant increases in population 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 aspects of the biology of South-Central California Coast steelhead (*e.g.*, the role of the resident form of *O. mykiss* in supporting the anadromous form, dispersal rates between watersheds, *etc.*), quantitative prescriptive criteria must be precautionary, while performance criteria require 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 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 the DPS is viable and 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.*, genetic, phenotypic, and behavioral diversity). Appropriate time scales will ensure the DPS will persist long enough 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 long-term viability.

The TRT viability criteria provide guidance for evaluating recovery of steelhead populations and the SCCCS DPS given the current level of knowledge and understanding of the biology and ecology of SCCCC steelhead. The recommended criteria carry varying levels of uncertainty depending on quantity and quality of available information on steelhead in the SCCCS Recovery Planning Area. Given the current level of uncertainty, NMFS has adopted many of the viability criteria as recovery criteria until sufficient scientific information is available to refine population DPS viability criteria. 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 determine 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 six 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 and successful persist in watersheds during drought conditions 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) are 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 smaller mean run sizes are 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 supporting residency may be critical to conserving the genetic diversity of steelhead. Preserving the resident life from may provide stock to 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. The mean annual run size necessary for viable anadromous *O. mykiss* populations is currently uncertain for the SCCCS Recovery Area and probably differs for different populations (and watersheds). The TRT estimated a prescriptive mean annual run size to accommodate this uncertainty by using a "random-walk-with-drift" model (Lindley 2003; see also Foley 1994, Lande 1993). This model used quantitative field data for one anadromous *O. mykiss* population and 19 Chinook salmon populations in California's Central Valley (Lindley 2007, 2003). Modeling results determined 4,150 spawners per year provided a 95 percent chance of persistence of a population over 100 years and applied to generalized situations where no quantitative field data on specific local populations is available (Boughton *et al*. 2007b). The estimation of the spawner abundance target incorporated a number of variables including 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 higher than necessary, especially in relatively small watersheds such as those along the Big Sur and San Luis Obispo BPGs which exhibit different characteristics such as shorter distances between individual watersheds and between the ocean and upstream spawning and rearing areas, a strong marine climatic influence, and generally steeper stream gradients. These BPGs may support viable populations at average runs sizes well below 4,150 (Boughton *et al*. 2007b). Factors that may be evaluated to refine the spawner viability target for these BPGs will likely include information such as reliability of access to spawning and rearing areas, escapement to the ocean, stability of freshwater environments, the supporting role of non-anadromous forms of *O. mykiss*, inter-watershed exchanges (by dispersal) of anadromous forms of *O. mykiss*. These factors may play an important role in stabilizing the life-history, and allow for refinement of the population-level recovery criteria, including a smaller mean run size that is sufficient for viability (Williams *et al.* 2011). Until research is undertaken and revisions are made to the prescriptive viability criteria, the population–level viability criterion for a demographically discrete or independent population of *O. mykiss* is 4,150. This target will be reviewed during NMFS' 5-year review of the Recovery Plan, and

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

potentially during the general 5-year status review updates for Pacific salmon and steelhead listed under the ESA.

The separate watersheds comprising each BPG are treated as individual steelhead populations for the purposes of meeting the run-size criterion (except the Salinas River basin, which supports three different populations). 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 use a precautionary approach towards determining run sizes for the individual populations. A precautionary approach will be framed to 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 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).

Performance-based criteria require better estimates 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 survival and growth rate during poor ocean conditions; and 3) the ability or inability of the resident form of *O. mykiss* (rainbow trout) to contribute progeny to steelhead populations and thereby bolster steelhead populations during periods of otherwise poor ocean survival.

Methods exist for estimating extinction risk through the use of time-series of spawner counts (Dennis *et al*. 2006, Lindley 2007, 2003, Holmes 2001; see also Beissinger and Westphal 1998). In general, about 20 years' worth of these data are necessary to obtain reasonable confidence for such estimates (Lindley 2007, 2003) to be used for the purposes of delisting the SCCCS DPS.

There is a 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, further underscoring the importance of initiating recovery actions. Boughton *et al.* 2007b) describe a decision tree for use in refining and establishing a viability criterion for mean population size. See also, Adams *et al*. (2011) for a proposed coast-wide strategy for monitoring California coastal salmonid populations.

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. This larger variance causes the number of fish to fluctuate, 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 can 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 due to 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 meeting 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 CDFW (Adams *et al.* 2011) recommends a series of "Life Cycle Monitoring Stations" to monitor smolts and spawners to evaluate ocean survival for individual populations (see Chapter 13, South-Central California Coast Steelhead Research, Monitoring, and Adaptive Management, Table 13-1). As performance-based run-size criteria are developed for the SCCCS DPS, the ocean conditions criterion may change, 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 widely distributed and at low abundance, populations can decline as a result of the difficulty in locating mates. However, a marginal benefit of a wide distribution is reduced vulnerability to localized catastrophes or environmental variations when occupying a broader range of habitats. If too densely packed within a limited spatial distribution, populations may be more vulnerable to unpredictable environmental events because all members of the population experience the same conditions. The TRT concluded that a viability criterion related to population spawner density (at some scale) was warranted, particularly for historically larger populations. A potentially suitable threshold for these purposes is the density at which intra-specific competition for redd sites becomes observable. For coho salmon 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, Santa Cruz County, to the Oregon border). This should provide sufficient data for deriving specific spawner density criterion. If these data are not sufficient to derive density criteria, redd-counts specific to the SCCCS Recovery Planning Area **may be necessary.**

Criterion P.4 – Anadromous Fraction. "Anadromous fraction" is the mean fraction of reproductive adults that are anadromous (steelhead) versus resident. Steelhead in the SCCCS Recovery Planning Area co-occur with rainbow trout. Elsewhere, steelhead have been observed to have resident forms 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, Hendry and Stearns 2004). 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 resident *O. mykiss* population prevents their complete disappearance. Recolonization can occur after steelhead disappear completely and are regenerated by the resident population via "recolonization" of the steelhead niche (Hendry *et al.* 2004). This phenomenon 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 in these watersheds 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 the rescue effect is negligible, and the anadromous fraction must be 100. Future research[3] on this topic could be used to estimate a viability threshold that is more efficient than the precautionary "100% rule."

6.3.1.2 DPS-Level Recovery Criteria

Criterion D.1 (.1, .2, and .3) – Biogeographic Diversity. This criterion contains three elements to 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 important components 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 sufficient populations are present within the BPG and across the DPS. This will provide resiliency in the face of environmental fluctuations (including projected long-term climate changes) and ensure a variety of habitat types and conditions are represented (*e.g.,* different stream gradients and estuary size,

[3] 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.

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 which has allowed them to exploit the wide diversity and range of habitat conditions characteristic of South-Central California. These life history forms include the fluvial-anadromous, lagoon-anadromous, and freshwater life history patterns. 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 in a semi-arid and highly dynamic environment including the ecological relationship between non-anadromous and anadromous populations;
- monitoring of existing populations; and
- implementation of the habitat protection and restoration actions to produce the suite of conditions necessary to promote all life history forms.

Criteria D.2 – Redundancy and Geographic Separation. Wildfires, droughts, and debris flows (triggered by wildfires followed by heavy precipitation) pose the greatest natural threats to entire populations (see for example, California Office of Emergency Services 2008, Gabet and Mudd 2006, Ellen and Wieczorek 1988, Wieczorek 1987). Preservation of the various life history forms of *O. mykiss* in a dynamic landscape requires redundancy and an effective separation of populations.

To ensure the survival of at least one viable population per BPG during a catastrophic wildfire season, two criteria must be met: 1) the number of viable populations in each BPG should outnumber the number of wildfires expected in a catastrophic wildfire season, and 2) if possible, populations should be spatially separated by a distance sufficient to prevent an individual wildfire from extirpating more than one viable population.

To determine the level of redundancy 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 interval and number were estimated for each BPG using standard methods. An analysis of the 1000-year fire scenario was used to determine the number of viable populations necessary for each BPG. Results indicate at least one viable population plus the maximum number of wildfires expected for the BPG, (or the number of historical viable populations in the BPG), whichever was less were need to ensure long-term resiliency. The recommended minimum geographic distance between individual viable populations should be 68km (42 miles). This distance was predicted as the minimum necessary to reduce the likelihood that the minimum number of viable populations would be extirpated a thousand-year wildfire event. The preservation of a necessary minimum number of viable populations within a BPG against debris flows is also achieved through the redundancy and geographic separation prescribed to protect against wildfire risk.

Droughts however, tend to occur over spatial scales broader than the Recovery Planning Area, and thus require a different strategy. Such a strategy involves maximizing the ability of fish to move in response to drying conditions by removing or modifying fish passage barriers; identifying and protecting drought resilient watersheds, that is those with over-summering refugia habitat; control of water extractions (both surface or groundwater); or in some cases the use of managed flows from reservoirs. (Boughton 2010a, Boughton *et al.* 2007b).

6.4 THREATS ABATEMENT CRITERIA

Current and future threats impeding recovery of the SCCCS DPS must be addressed and must meet the population and DPS-level recovery criteria described above. Basic threats abatement criteria identified below are used to track recovery efforts. The identified existing and future threats fall within the categories of listing factors identified during the species listing process (see Chapters 9-12, sub-sections 9.4-12.4 for each BPG). Each listing factor 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, the severity of the threat, 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 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 (for definition of listing factors see Chapter 3, Factors Contributing to Decline and Federal Listing). 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 ensure individual populations essential to the recovery scenario are not further degraded. 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 ***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 threats abatement criteria.[4]

Threat	Current Threat Level	Recovery Action Rank	Target Abatement Level for Recovery
Dams and Surface Water Diversions		1A	
Groundwater Extractions		1B	
Culverts and Road Crossings (Passage Barriers)		1B	
Wildfires		2B	
Urban Development		2B	

[4] Note: This table is only intended to illustrate the application of the threats abatement criteria, to the various Recovery Action Priority categories (1A, 1A, 1B, 2B) and not the priority of threats or ranking of individual recovery actions across the SCCCS DPS, or any specific watershed. For threat rankings in individual watersheds see the Biogeographic Chapters 9-12.

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, though not eliminated, 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:

- Freshwater migration corridors supporting viable populations meet the steelhead life history and habitat requirements (Listing Factors 1, 3, 4, and 5).
- Viable populations have unimpeded access to previously occupied habitats (Listing Factors 1, 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).
- 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).
- Adequate funding, staffing, and training are provided to city, county, 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).

The threat source ranking for each component watershed is presented in BPG Chapters 9-12; a description of the CAP workbook method 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 delisting the SCCCS DPS. Restoring access to a diversity of steelhead habitats and restoring the ecological functions of those habitats to properly functioning conditions are central to the recovery of the SCCCS DPS. This biologically based strategy aims to restore the natural selective regime under which steelhead evolved and which is critical to their long-term survival (Dunlop *et al.* 2009, Propst *et al*. 2008, Lytle and Poff 2004, Bunn and Arthington 2002, Poff *et al*. 1997).

The recovery strategy identifies watersheds where recovery of viable populations is necessary to achieve the recovery DPS 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) necessary to reverse the effects of past and ongoing threats to population abundance, growth rate, diversity, and spatial structure. An integral element in this recovery strategy is development and implementation of a research and monitoring program which will provide 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 the SCCCS DPS will require effective implementation of 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 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 native 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 areas.

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 patterns and associated wildfires will create challenges in maintaining traditional water supply and flood control structures such as dams, levees, and channelized watercourses. Engineered systems which control hydrological systems have often been overvalued and frequently overwhelmed when their design parameters are 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 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, Ligon *et al.* 1995, 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 provides an opportunity to meet a 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 or species of special concern such as Foothill yellow-legged frog (*Rana boylii*) California red-legged frog (*Rana aurora draytonii*), Least Bell's vireo (*Vireo bellii pusillus*), California least tern (*Sterna antillarum browni*), Western snowy plover (*Charadrius alexandrinus nivosus*), Arroyo toad (*Bufo microscaphus californicus*), Tidewater goby (*Eucyclogobius newberryi*), and Pacific lamprey (*Entosphenus tridentata*) that co-occupy the SCCC Recovery Planning Area.

Under present conditions, the viability of individual populations is more likely achievable by focusing recovery efforts on larger watersheds (with some notable exceptions within the San Luis Obispo Terrace BPG) 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) the development of site-specific and project specific information, to ensure that recovery actions are effective and sustainable; 2) 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; 3) 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; 4) close cooperation with other state resource agencies such as the California Department of Fish and Wildlife, California Coastal Commission, CalTrans, California Department of Parks and Recreation, State Water Resources Control Board, and Regional Water Quality Control Boards to ensure consistency of recovery efforts; and 5) 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, National Resource Conservation District, 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 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; establishment and implementation of appropriate flow regimes for individual watersheds; and 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 also addressing new threats that emerge over time. NMFS estimated the costs associated with certain common restoration activities such as those undertaken as part of the CDFW Fisheries Restoration Grants Program. Appendix E, Recovery Actions Cost Estimates For Steelhead Recovery Planning, contains preliminary estimates for these categories of typical watershed and river restoration actions.

7.1.1 Funding Recovery Actions

Many of the recovery actions identified in the recovery action tables in Chapters 9 through 12 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, also 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 Wildlife 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***
- ***County Fish and Wildlife Advisory Commissions*** (Santa Cruz, Santa Clara, San Benito, Monterey, San Luis Obispo Counties)

Many of these grant programs also offer technical assistance, including project planning, design, permitting, monitoring. Additionally, regional personnel with NOAA, CDFW, and the U.S. Fish and Wildlife Service can provide assistance and current information on the status of individual grant programs.

7.2 CORE POPULATIONS

The findings of the TRT (Boughton *et al*. 2007b, 2006) and additional review by NMFS indicate certain watersheds and their steelhead populations 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 summer and reliable winter streamflow, stream network extending inland) most likely to sustain independently viable populations, and that are critical for ensuring the viability of the DPS as a whole. Population viability is more likely achievable by focusing recovery efforts on these watersheds in each BPG capable of sustaining viable populations, though the recovery strategy also identifies a role for smaller watersheds which may serve as important sources of fish dispersed between larger watersheds (see Table 7-1 below). DPS viability is more likely achievable by focusing on the most widely-dispersed set of 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 populations identified as the highest priority for recovery 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.

Core 2 populations are generally smaller populations, and may have less diverse and complex threats than Core 1 populations, though the conditions in individual cases vary considerably. Core 1 populations and Core 2 populations are the principal focus of identified recovery actions.

Core 3 populations are generally the smallest populations with lowest intrinsic potential, though within the Big Sur Coast and San Luis Obispo Terrace BPGs, the viability of these populations may rely less on population size than on other factors such as reliability of access to upstream spawning and rearing habitats and more stable hydrologic and thermal conditions. As with Core 2 populations, Core 3 generally have less diverse and complex threats, though the conditions in individual cases varies considerably, and may be important in meeting the DPS viability criteria.

The weight given these factors in designating populations as either Core 1, 2 or 32 may vary with individual watersheds. Generally larger watersheds with the highest intrinsic potential, such as the Salinas and Pajaro, are designated Core 1 populations (see Appendix B for the relative intrinsic potential rankings of watersheds evaluated as part of the recovery planning process). 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 essential to the recovery of the DPS as well as on watersheds with greatest need for recovery actions.

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

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, though several Core 2 populations along the north portion of the San Luis Obispo Terrace Biogeographic Population Group such as San Carpoforo and Arroyo de la Cruz Creeks are important as relatively unimpaired references streams for chaparral dominated watersheds (see 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. These Core 2 populations are ranked differently than Core 1 populations based on the factors noted above; NMFS recognizes timing of recovery actions on these populations may also 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 the same priority as Core 1 and 2 populations, these populations may be important in providing connectivity between populations and genetic diversity across the SCCCS Recovery Planning Area, and therefore are an important 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-basin 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 a critical component of the recovery strategy is securing extant inland populations in the 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. The populations of the Interior Coast Range and Carmel Basin BPGs are particularly important because they 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 populations 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 identified individual populations are not viable, restoration of more closely spaced populations (e.g., Islay or Coon Creek) 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, Coon, or Islay 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, questions remain regarding species ecology (*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 actively pursuing recovery opportunities in Core 3 watersheds as a precaution to reduce extinction risk. 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

Recovery actions are the critical elements for alleviating major threats to steelhead in Core populations. 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 are the highest priority across the SCCCS DPS and within Core populations to achieve recovery objectives and criteria. The highest priority actions have a priority ranking of 1, and generally address threats related to reduced flows and impediments to fish passages that result in the destruction or curtailment of steelhead habitat. 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), 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 significance 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 adverse impact to steelhead and their habitat. However, two types of developments and activities generally pose the most widespread threats to the species in these watersheds (and the DPS as whole): 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, the recovery strategy places a high priority on recovery actions alleviating 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; this will entail, among other things, restoration and protection of upstream spawning and rearing habitats, rearing habitats in coastal estuaries as well as other potential refugia rearing habitats, and controlling or eliminating non-native species such as those in artificial reservoirs above dams. 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 (Tables 9-4 through 9-6, and Tables 12-4 through 12-13).

Regarding the impacts of impassable anthropogenic barriers on threatened steelhead, the recovery objectives include restoring steelhead distribution to previously occupied areas and restoring genetic diversity and natural interchange within populations and metapopulations. One of the threats abatement criteria identified to meet these objectives is allowing sustainable effective access to historical spawning and rearing habitats. Historical habitats are often situated in protected areas such as the Los Padres National Forest, and provide essential attributes for spawning and rearing such as suitable substrate, sustained base flows, and pool habitats. In addition to allowing access to historical habitats, dam modification provides additional ecological benefits essential to attaining recovery objectives. 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) through restoration of the natural spatial population structure. Mechanistic solutions to fish passage impediments 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), Agostinho *et al.* (2002), Oldani and Baigum (2002), Nemeth and Kiefer (1999), Cada *et al.* (1995, 1993), Clay (1995), 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 steelhead ecosystems. See for example, Wegner *et al.* (2011, 2010), Carlisle *et al.* 2010, Marks *et al.* (2010), Poff and Zimmerman (2010), Poff *et al.* (2010, 1997), Annear *et al*. (2009, 2004), Instream Flow Council (2009, 2004), Olden and Naiman (2009), Lytle and Poff (2004), Bunn and Arthington (2020, 2007, 2006), Gibbons *et al.* (2001), Hatfield and Bruce (2000), Vadas (2000), Kraft (1992), MacDonald *et al*. (1989).

Recovery of the SCCCS DPS requires restoration of 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. 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 more natural streamflow patterns are restored (*i.e.,* timing, frequency, duration, magnitude, and rate-of-change). There are many sites within Core watersheds where past and present anthropogenic activities alter the pattern and magnitude of streamflow and for which essential recovery actions are identified. In some situations, 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. 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.* 2012, 2008, Casagrande 2012, 2010a, Bond 2006, Smith 1990, Moore 1980). Two other habitats are streams with high summer flow (sometimes augmented by releases from reservoirs or reclaimed water) or in-channel impoundments like Sprig Lake on a seasonal tributary to Uvas Creek that may provide drought resistant refugia habitat for rearing juvenile *O. mykiss* (Smith 1982, 2007a, Casagrande 2011, 2012, 2010a, Moore 1980). The identification, protection, and where necessary, restoration, and/or creation of such habitats should be considered as important recovery actions.

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 conditions in watersheds throughout the entire extent of the DPS, local stakeholders should continue to undertake actions that complement the essential recovery actions in Core 1 watersheds.

To focus recovery efforts and facilitate recovery, the Recovery Plan identifies populations essential to meeting recovery goals and criteria (Core 1, 2, and 2 populations) in each of the four

BPGs within the DPS, and prioritizes recovery actions for each of the watersheds within the BPGs (see Recovery Action Tables in Chapters 9-12).

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) preserving the remaining genotypic and phenotypic characteristics promoting life history variability though captive broodstock, supplementation, and gene-bank programs to reduce short-term risk of extinction; and 3) reintroduction of populations into restored watersheds. However, conservation hatcheries should not serve as surrogates for establishing and preserving essential habitat functions for threatened steelhead, particularly where anthropogenic activities have created threats constraining or eliminate habitat functions and values.

Issues that should be closely 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).

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	Develop and 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 fish passage impediments, (*e.g*. 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 and restoration of spawning gravel recruitment to the lower mainstem (*e.g.,* Uvas Creek). Manage instream mining to minimize impacts to migration, spawning and rearing habitat in major tributaries, including Uvas, Corralitos, Llagas, and Pacheco Creeks, and the San Benito River. Identify, protect, and where necessary, restore estuarine rearing habitat, including management of artificial sandbar breeching at the river's mouth.
	Salinas River	Develop and implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases from the Salinas 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 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, including management of artificial sandbar breeching at the river's mouth.
	Arroyo Seco	Develop and implement operating criteria to ensure the pattern and magnitude of groundwater extractions from the Arroyo Seco and lower Salinas River provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify fish passage impediments, including concrete road crossing and diversion structure 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	Develop and 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	Develop and implement operating criteria to ensure the pattern and magnitude of water 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	Develop and implement alternative off channel water supply projects to eliminate or decrease water extractions from the channel (including subsurface extractions), and implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases from San Clemente and Los Padres Dams provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or physically modify San Clemente, Los Padres, and Old Carmel River Dams to provide steelhead natural rates of migration to upstream

		spawning and rearing habitats; passage of smolts and kelts downstream to the estuary and ocean; and restoration of spawning gravel recruitment to the lower mainstem. In the interim ensure provisional fish passage of both adult and juvenile O. *mykiss* around Los Padres, San Clemente and Old Carmel River Dams, and seasonal releases from San Clemente and Los Padres Dams to support all *O. mykiss* life-history phases, including adult and juvenile migration, spawning, and incubation and rearing habitats. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats (including supplemental water to the estuary, management of artificial sandbar breaching at the river's mouth, and provision of spawning gravel and large woody debris within the lower mainstem).
Big Sur Coast	San Jose Creek	Development and 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 rearing habitat, including management of artificial sandbar breeching at the river's mouth, and upstream freshwater spawning and rearing habitats.
	Little Sur River	Develop and 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 spawning and rearing habitats.
	Big Sur River	Develop and 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 spawning and rearing habitats. Consideration should also be given to establishing fish passage to the upper reaches above the rock cascade within the lower gorge.
San Luis Obispo Terrace	San Simeon Creek	Develop and 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. Manage instream mining to minimize impacts to migration, spawning and rearing habitat. Identify, protect, and where necessary, restore estuarine rearing habitat, including management of artificial sandbar breeching at the river's mouth, and upstream freshwater spawning and rearing habitats.
	Santa Rosa Creek	Develop and 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 rearing habitat,

		including management of artificial sandbar breeching at the river's mouth, and upstream freshwater spawning and rearing habitats.
	San Luis Obispo Creek	Develop and 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, diversions , and culverts, 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 rearing habitat, including management of artificial sandbar breeching at the river's mouth, and upstream freshwater spawning rearing habitats.
	Pismo Creek	Develop and 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 rearing habitat, including management of artificial sandbar breeching at the river's mouth, and upstream freshwater spawning and rearing habitats.
	Arroyo Grande Creek	Develop and 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 rearing habitat, including management of artificial sandbar breeching at the river's mouth, and upstream freshwater spawning and 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, requiring adequate flows and unobstructed migration routes to move between marine and freshwater habitats, including 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 Wildlife 2012a, 2012b; see Figure 7-1). Restoring steelhead access to historical spawning and rearing habitats (*i.e.,* areas upstream of introduced barriers to areas currently unoccupied by anadromous *O. mykiss*) is an essential action for recovering threatened steelhead.

Reestablishing access to currently unoccupied areas is essential for conserving threatened steelhead (Boughton *et al.* 2007b, 2006) in the SCCCS DPS. Additionally, the characteristics and condition of historical habitats must remain functional to support their intended conservation role. Implementing these recovery actions will require removing or physically modifying anthropogenic barriers, concurrently with protecting, and where necessary, restoring these habitats.

The following discussion summarizes the ecological rationale for these recovery actions. Central to the rationale is the historical steelhead population structure and distribution, and the necessity of restoring access to historically highly productive steelhead spawning and rearing habitats as a means to increase the population growth rate (*i.e.,* the productivity of a population), and thus reduce the extinction risk to these populations.

Native steelhead historically existed in areas that are currently inaccessible.

A review of the scientific and historical literature on the distribution of steelhead within the SCCCS Recovery Planning Area indicates steelhead were widespread up until the mid-20th century. See for example, Becker *et al*. (2008), Boughton *et al.* (2006), Boughton and Goslin (2006), Boughton *et al.* (2005), Boughton and Fish (2003), Swift *et al.* (1993), Nehlsen, *et al.* (1991), Wells *et al.* (1975), Boydstun (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 the present-day populations are dominated by individuals with ancestry from 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 persist upstream of anthropogenic barriers are largely or entirely descended from relic *O. mykiss* populations. These findings, as well as the intrinsic potential of certain watershed-specific populations for recovering this species, underscore the importance 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 (in combination with associated alteration of flows and habitat complexity) 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 access to historical steelhead habitats is necessary to reduce extinction risk to a level that is considered negligible over a 100-year period.

Population extinction risk is related to the numerical abundance of the population, which itself is related to the species' areal distribution (*i.e.*, population spatial structure) and the degree the diversity of life history traits are unrestricted. Small populations with limited spatial structure are particularly susceptible to extinction, owing to 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. These characteristics reflect their adaptation to variable freshwater and marine environments. Generally, 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 reduces its extinction risk to a negligible level (Boughton *et al.* 2006, McElhany *et al*. 2009, 2000).

Throughout the SCCCS Recovery Planning Area, anthropogenic activities have severely truncated population spatial structure through construction of instream structures that have inhibited or blocked completely fish migration. These artificial barriers have eliminated the expression of certain life history traits in individual watersheds such as the Nacimiento and San Antonio Rivers, 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 Wildlife (2012a), Boughton *et al.* (2005).

While steelhead were historically widespread, artificial migration barriers (including those caused by reduced flows) have resulted in populations that are spatially restricted 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. Additionally, barriers preclude steelhead from accessing upstream spawning habitats and interacting with the freshwater form of *O. mykiss*, which contribute to the diversity of the *O. mykiss* complex. Ensuring this life history attribute is persevered will facilitate species resiliency by helping it withstand stochastic environmental fluctuations.

Because reduced and degraded habitat conditions within the SCCCS DPS has negatively affected the abundance, diversity, spatial structure, and growth rate of 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 within those habitats 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.

Available information describing the current abundance and distribution of *O. mykiss* indicates habitats historically accessible to steelhead still 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, reported on the distribution of *O. mykiss* habitat, including in areas upstream of artificial barriers within Core

1 populations. These investigations indicate existing habitats above artificial barriers are suitable for spawning and rearing of *O. mykiss*, as evident by the finding of young-of-the-year and older juvenile rainbow 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 because 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 Wildlife (2006), Thomas R. Payne and Associates (2005).

With regard to the amount of suitable steelhead habitat above artificial barriers, the findings of fishery investigations and habitat evaluations indicate the existence of hundreds of miles of stream network across the Core 1 populations, though some reaches may be impacted by development or land uses practices, and require restoration Such areas will require evaluation on a case-by-case basis as part of any proposal to re-establish access. Numerous streams within Core 1 watersheds provide an extensive habitat 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, 1998, 1997, 1996, Nelson *et al*. 2006a, 2006b, 2005a, 2005b, Thomas R. Payne and Associates 2004, 2001, Hagar 2001, Londquist 2001, D. W. Kelley & 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. However, each anthropogenic barrier must be assessed on a case-by-case basis. For example, some dams and associated reservoirs within the SCCC DPS such as Uvas Dam on Uvas Creek, San Antonio and Nacimiento Dams within the Salinas River watershed, and the Los Padres Dam on the Carmel River, are important parts of a regional water supply system, and their modification or management must take into account their existing and future functions. Additionally, as noted previously, restoring access to habitats above anthropogenic barriers, will potentially entail controlling or eliminating non-native species established in reservoirs above dams, and in some cases where habitat above dams has been degraded, restoration of habitat conditions (*e.g.*, riparian cover, instream habitat complexity, including adequate spawning substrate).

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 experience gained in this effort has led to a growing understanding of the technical, logistical and regulatory issues necessary to effectively and efficiently remove or modify fish passage habitat and restore habitat characteristics. 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), 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), Babbitt 1998, Williams and Wolman (1984).

Regionally, NMFS has collaborated with project proponents on a variety of fish-passage projects that have involved removal or modification of highway structures, diversions, or dams 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. These dams are being removed to allow anadromous salmonids natural access to historical spawning and rearing habitats (Capelli 2007, Wunderlich *et al*. 1994). Where dams are not removed, existing fish passage facilities may be required to be up-graded, or where no fish passage facilities exist, the dam may be retrofitted to provide effective fish passage, both for upstream and downstream migrating fish.

With regard to the expected success from restoring steelhead migration to historical habitats, making fish passage 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 is anticipated steelhead productivity will increase substantially, and therefore contribute to the resilience of the population.

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 and Joyce 2004, Thrower *et al*. 2008, 2004a, 2004b). Even today, large adult *O. mykiss* leave the freshwater lakes that have formed behind dams (such as Whale Rock Reservoir on Old Creek in San Luis Obispo County), 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, when reduced, it can adversely affect evolutionary processes and impair the ability of a population to adapt to spatial or temporal environmental changes. Populations with low density (*i.e.,* few fish per mile) are susceptible to low growth rates and loss of genetic diversity, and are more likely to be adversely affected by widely fluctuating environmental conditions, including longer term climate change.

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 currently impaired conditions. For example, extended periods of no or low rainfall can limit migratory conditions and preclude steelhead from reaching freshwater spawning areas. 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 *successfully* 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 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 2008, Wilson 1971), a larger number of individuals decrease the risk of extinction.

7.5 RESTORING STREAMFLOW REGIMES IMPACTED BY DAMS, DIVERSIONS, AND GROUNDWATER EXTRACTIONS

Recovery actions for specific watersheds across the SCCCS Recovery Planning Area provide that the "natural" pattern and magnitude of streamflow must be restored (or approximated) if threatened steelhead are to be recovered. Generally, this recommendation is based on the flow-related dependency of many features of aquatic habitat and the inextricable connections among streamflow, riverine habitat, and steelhead life history, habitat requirements, and population metrics (*e.g*., Harvey *et al*. 2006, Spina *et al*. 2005, Kondolf 1987, Poff *et al.* 1997, Ligon *et al*. 1995, Barnhart 1986, Shapovalov and Taft 1954).

Steelhead have evolved strategies such as opportunistic migration and utilization of available spawning habitat throughout a watershed in response to rainfall-induced streamflow events in the SCCCS Recovery Planning Area. Artificial modification of streamflow regimes, particularly reduction of the duration, frequency, and magnitude of streamflows and hydrologic connectivity between the marine and estuarine environment and upstream spawning and rearing tributaries, has adversely impacted the steelhead SCCCS DPS. The significance of this threat is reflected in the CAP Workbooks, which explicitly identify groundwater extraction, water diversions, and water storage facilities as a Very High or High Threat in most watersheds. Only the smaller streams within the Big Sur Coast BPG appear to be generally unaffected by extensive water development (though groundwater extraction is ranked as a Very High threat in two of these watersheds – San Jose Creek and Big Sur River). See threat source rankings tables in Chapters 9 through 12.

Although there is a general understanding of the ecological effects of modified flow regimes on steelhead, a level of uncertainty still remains. In particular, understanding how fish movement and utilization of microhabitats is impaired by temporal and spatial variation in connectivity between different parts of a watershed is limited. In the SCCC Recovery Planning Domain streamflows during the dry season are highly variable and reduced further by water development to meet human demands. As a result, an improved understanding of the relationships between streamflow and the maintenance of steelhead populations is necessary for the recovery of the SCCCS DPS (Booth *et al*. 2013, Grantham 2013, 2010, Kondolf *et al.* 2012, Grantham *et al.* 2012, Nislow and Armstrong 2011, Bond *et al*. 2010, Anderson *et al.* 2006, Acreman and Dunbar 2004, Annear *et al.* 2009, 2004, Bayley 2002, Hatfield and Bruce 2000, Richter *et al.* 1997, Castleberry *et al*. 1996).

The role of streamflow in the life-history of anadromous *O. mykiss* is complex, but can be divided into two basic categories: 1) creation and maintenance of essential freshwater habitat, principally for spawning and rearing, and 2). support migratory behavior and ecology for both adults and juveniles in freshwater habitats. Knowledge of this role contributes to a broader understanding of why restoring the natural streamflow regime is a prerequisite for recovering threatened steelhead. Following the description of this role, we provide considerations for restoring the natural pattern and magnitude of streamflow.

Creation and maintenance of essential freshwater habitat.

The erosive forces of streamflow operating on underling geology and land forms, and in conjunction with vegetative cover, is principally responsible for creating a wide variety of habitats used by steelhead to complete the freshwater phase of their life-cycle. The creation of basic stream channel morphologic features (pools, runs, glides, undercut banks, gravel bars, *etc*.), and lagoon sandbar formation and breaching is an important function of streamflow. Other basic functions of streamflow include the flushing of fine sediments, distribution of nutrients, recruitment and sorting of spawning gravels and large woody debris, and maintenance of riparian vegetation (Meissen *et al.* 2013, Wilcox and Shafroth 2013, Rich and Keller 2013, 2011, Leigh *et al.* 2010, Harrison and Keller 2006, Fausch *et al*, 2001, Montgomery and Buffington 1997, Poff *et al.* 1997, Kondolf and Wilcock 1996, Reeves 1996, Leopold 1994, Calow and Petts 1992, Bjornn and Reiser 1991, Resh *et al.* 1988, Faber *et al*. 1989, Knighton 1984, Keller and Swanson 1979, Reid and Wood 1976, Hynes 1970).

Streamflows control a number of features of aquatic habitats that are of critical importance to the freshwater phase of the steelhead life cycle. For example streamflows in combination with the physical channel geometry and roughness control the velocity, depth and volume of water within various instream habitats, and consequently, the amount, suitability, and connectivity of habitat available to steelhead, including juvenile steelhead rearing instream. Streamflow patterns are closely associated with water quality, including temperature, dissolved oxygen, the concentration of pollutants, and are responsible for the production and delivery of food sources for juvenile steelhead, affecting their growth rates and survival (Grantham *et al.* 2012, Nislow and Armstrong 2012, Wegner *et al.* 2011, Annear *et al.* 2004, Myrick and Cech 2004, Zedonis and Newcomb 1997, Bjornn and Reiser 1991). Overall, streamflow creates and maintains living space and related features for steelhead that are essential for long-term growth and survival of this species.

Understanding the relationships between low flow conditions during the dry season (late spring through late fall) and juvenile steelhead survival is particularly important in California where natural low flows often coincide with peak water extractions for out of stream uses such as agricultural irrigation, either through direct diversion or groundwater withdrawals. Field investigations in central California have shown a strong correlation between summer flows and survival of oversummering juvenile steelhead (Grantham *et al.* 2012, Kondolf *et al*. 1997).

Support for migratory behavior and ecology of adult and juvenile steelhead in freshwater habitats.

Steelhead are a migratory species that require a properly functioning migration corridor for moving to and from the marine and freshwater environment (and between stream reaches within the freshwater environment) to complete their life cycle. In this context, the functional value of hydrology in the migratory behavior and ecology of steelhead in South-Central California watersheds can be best understood by considering the following:

(i) In arid regions, rainfall events can trigger periods of elevated discharge that serve as the primary environmental cue for migration of steelhead into, within, and out of a watershed. As such, the elevated discharge promotes migration opportunities for this species that would otherwise not exist;

(ii) Streams in South-Central California watersheds can experience high runoff of short duration, and peak counts or observation of steelhead migrants coincide with elevated discharge steelhead. This underscores the functional value and importance of periods of elevated discharge for migration of steelhead in this region;

(iii) Steelhead show positive rheotaxis (facing into a current) and therefore more easily navigate streams at higher rather than lower discharge;

(iv) Migration synchronized to the seasonal occurrence of elevated streamflows (timing) is adaptive and increases the chance of species survival (*e.g.,* Lytle and Poff 2004); and,

(v) Steelhead do not enter and subsequently migrate upstream throughout a watershed as a single "run," but rather enter river systems in "waves," with each rainfall-induced discharge event prompting more steelhead to enter a river, and in-river adults to migrate farther upstream, ultimately to the upper spawning reaches. This behavior reflects an evolutionary adaptation to the rainfall and runoff pattern of the South-Central California watersheds, and underscores the ecological importance of frequent rainfall events, of extended duration, and the unimpaired movement of fish throughout the watershed.

Considerations for restoring the natural pattern and magnitude of river discharge to support freshwater steelhead migratory, spawning and rearing habitats.

Steelhead morphology, physiology, and behavioral characteristics have been shaped by biotic and environmental influences over ecological time to exploit and cope with naturally varying seasonal instream flow conditions. However, evidence indicates that artificial changes to the natural streamflow pattern and magnitude can preclude steelhead from completing essential life-history functions. The SCCCS Recovery Plan identifies a series of critical recovery actions for individual Core watersheds. One of the most fundamental actions for the recovery of the species is the regulation of surface and subsurface water diversions and extractions to ensure that the pattern and magnitude of surface flows provide the essential habitat functions to support the life history and habitat requirement of adult and juvenile steelhead; this includes the provision of streamflows necessary to support steelhead migration, spawning and rearing (see Tables 9-3 through 12-3 in Chapters 9-12).

In general, while it is often not possible to re-create original flow conditions, the closer that the managed ("restored") streamflow regime mimics the natural or pre-impact streamflow regime, the more likely the managed streamflow regime will meet the life history requirements of fishes and perpetuate a viable steelhead population indigenous to a particular watershed (Crow *et al.* 2012, Auerbach *et al.* 2012, Poff and Zimmerman 2010, Dunlop *et al*. 2009, Enders *et al*. 2009, Jowett and Biggs 2009, Kendy *et al.* 2009, Propst *et al.* 2008, Lytle 2004, King *et al.* 2003, Bunn and Arthington 2002, Poff *et al* 1997).

Providing a restored streamflow regime that closely resembles the pre-modified streamflow regime in a watershed requires that certain features of the pre-modified streamflow regime be known and understood in sufficient detail (including long-term natural variations in the flow regime). While a number of streamflow-assessment and development methods exist, only those methods that are capable of guiding derivation of a pattern and magnitude of streamflow that reflects or approximates the natural or pre-impact pattern and magnitude of streamflow are expected to promote recovery of threatened steelhead. In contrast, methods that promote the establishment of "minimum streamflows" are not expected to favor recovery of this species because these approaches generally fail to produce the kinds of hydrologic features and conditions that are necessary for unrestricted expression of life history traits and fulfillment of habitat requirements. Many of the existing methods have not been specifically developed for anadromous steelhead (Milner *et al.* 2012, Moyle *et al.* 2011, Palau *et al.* 2010, Deitch *et al.* 2012, 2009, Poff *et al.* 2009, Orth and, Arthington *et al.* 2007, Huckstorf *et al.* 2008, Murchie *et al.* 2008, Orth 2006 1987, Acreman and Dunbar 2004, Rosenfeld 2003, Tharme 2003, Marmulla 2001, Reiser *et al*. 1989, Estes and Osborn 1986, Orth and Maughan 1982, Wesche and Rechard 1980).

One of the most widely used is the Instream Incremental Flow Method (often referred to as "IFIM") and its microhabitat component model, the Physical Habitat Simulation Model. The IFIM method provides a structured process for identifying habitat information needs, target species, study sites, conducting hydraulic and habitat modeling, determining limiting factors, and evaluating management alternatives (Bovee *et al*. 1998, Stalnaker *et al.* 1995, Milhous *et al*. 1984, Bovee 1992, 1986). The method, however, is generally applied to selected river or stream reaches, and not to entire watersheds, and was not specifically designed for anadromous fishes, or habitat forming and sustaining fluvial processes which operate on watershed-wide and extended time-scales (such as spawning gravel recruitment and pool formation), which may vary substantially with geographic location and individual watershed characteristics. The literature reviewing the limitations of this method is extensive, though there is no consensus currently on how its methods may apply to anadromous salmonids, and steelhead in particular (Moyle *et al.* 2011, Souchon and Capra 2004, Parasiewicz 2007, 2003, 2001, Payne 2003, Hatfield and Bruce 2000, Armour and Taylor 1991, Gore and Nestler 1988, Orth 1987, Scott and Shirvell 1987, Shirvell 1986, Mathur, *et al.* 1985, Orth and Maughan 1982).

The approach that NMFS applies when developing streamflow recommendations for steelhead in south-central and southern California generally involves quantitatively estimating the unimpaired pattern (*i.e.,* timing, frequency, duration, and rate-of-change) and magnitude of streamflow in the subject waterway. Specific numerical metrics are gleaned from the hydrologic estimates and subsequently used in collaboration with stakeholders as a basis to guide development of the streamflow recommendation. The principal benefit of this approach involves using a knowledge of the natural or pre-impact pattern and magnitude of streamflow, and therefore the very characteristics and conditions that are responsible for evolution of the species' essential life-history traits and pre-impact population abundances and population growth rates, to guide development of the streamflow recommendation. Thus, while the specific relationship between steelhead population viability in the planning area and streamflow magnitude continues to emerge, estimates of the unimpaired pattern and magnitude of streamflow can be used as meaningful ecological surrogates for promoting viability.

It is widely recognized that water is a limited resource. As a result, the approach NMFS has adopted in its efforts to restore the natural streamflow regime accounts for the arid climate and related limited availability of water. To ensure that naturally limited water resources are allocated wisely and efficiently, NMFS' streamflow recommendations, including water releases from water projects, reflect criteria that promote synchrony of water releases with natural hydrologic conditions and the instream timing of specific steelhead life stages. Based on NMFS' experience collaborating with stakeholders within the SCCCS Recovery Planning Area and throughout California, objectives guiding water-management needs and recovery of the species are compatible when stakeholders are willing to engage in effective collaboration and innovation.

NMFS recognizes that restoration of the "natural" streamflow regime may not be possible or practical in certain waterways owing to the complexity of modifying water-management operations that local communities and agricultural activities rely upon. However, this expectation should not preclude stakeholders from collaborating with NMFS, and other resource managers such as the CDFW, in efforts to define streamflow recommendations that represent an approximation of the natural or unimpaired streamflow regime.

Stakeholders should be aware that while reaching agreement on an ecologically meaningful streamflow recommendation represents an important initial step for promoting recovery of steelhead, much uncertainty regarding the response of individual populations to a new streamflow regime typically exists at the onset. For example, numerical increases in abundance of steelhead smolts or unimpaired migration rates of immigrants and emigrants, will largely be unknown. To address these and other uncertainties, an adaptive management approach based on the collection of empirical data will be essential.

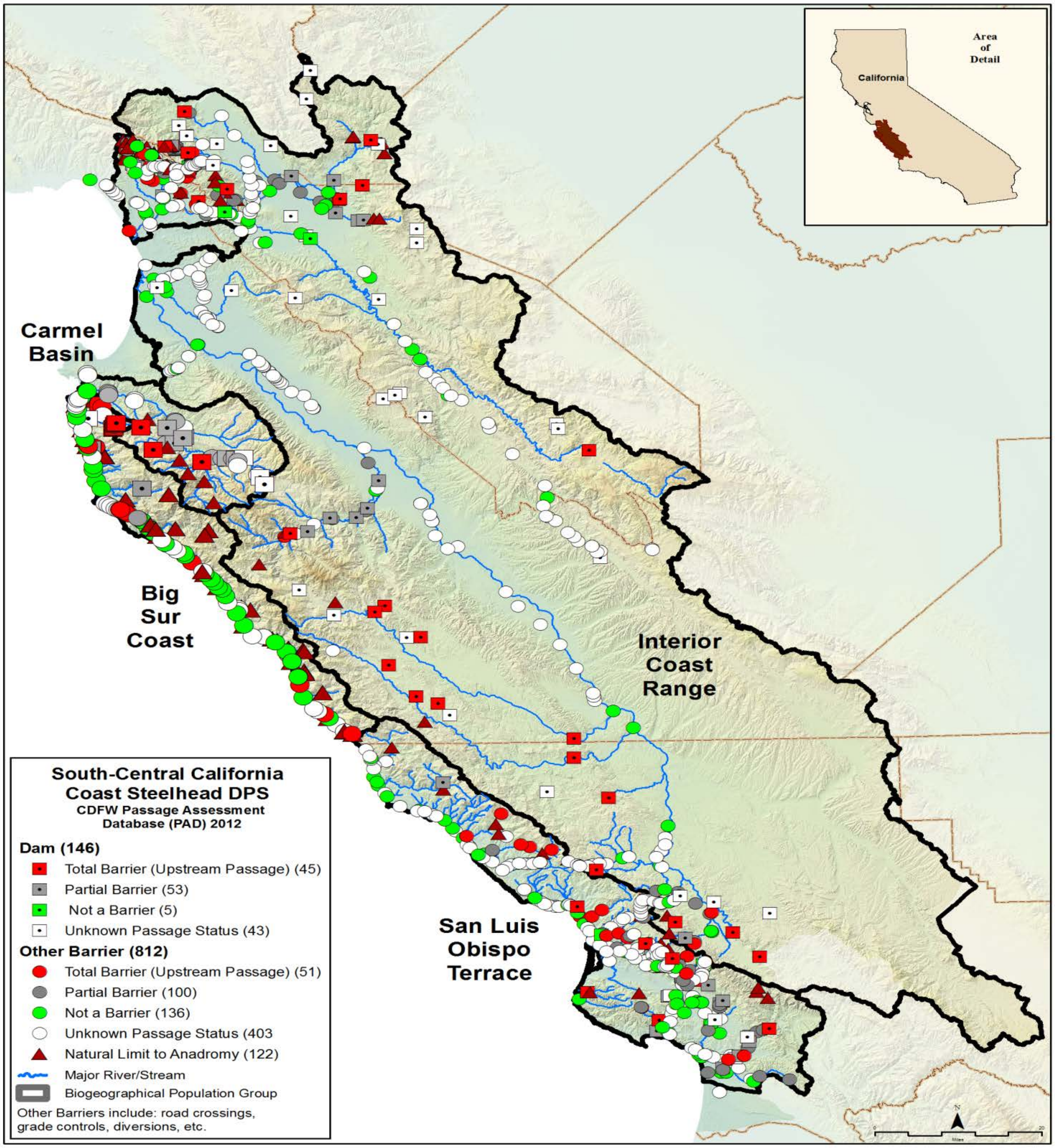

Figure 7-1. South-Central California Coast Steelhead DPS Known and Potential Fish Passage Impediments. Note: the status of fish passage barriers is in flux, with existing ones being removed or modified, while new ones may be installed, or discovered through updated inventories; a current list of priority fish passage impediments can be found on the California Department of Fish and Wildlife website: http//www.cafishpassageforum.org/

7.6 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; or 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; see also Bower *et al.* 2004):

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 historical 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, specific recovery actions within watersheds of each of the five BPGs which are intended to address and ameliorate specific adverse effects from projected climate change and related oceanic conditions were identified. Identified actions 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 to ensure the species will persist over an extended period of time, including long-term (decadal) marine cycles. SCCCS 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 (see Chapter 5, South-Central California Coast Steelhead and Climate Change).

7.7 CRITICAL RESEARCH NEEDS FOR RECOVERY

Successful implementation of the recovery plan and measurement of the species' progress towards recovery requires two additional critical elements: 1) population abundance monitoring (including rearing juveniles, smolts, and returning adults) within core watersheds and, 2) a variety of 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 improve 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 smolts which will exhibit an increased survival rate in the marine environment, 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 affecting 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 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 urban and agricultural 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 connecting upstream spawning and rearing habitats with the ocean, many 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 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 designed to address widespread and often multiple threat sources across the SCCCS Recovery Planning Area. These actions address issues 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 the SCCCS DPS. Many of these causes of decline are systemic and persistent, crossing numerous geographic 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.

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 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 and manage withdrawals from riparian wells, and through the provision of technical assistance and grants, develop rain/runoff collection facilities to address 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.
- Collaboration with local, state and federal agencies on local flood control and management programs (*e.g.*, the Pajaro River Bench Excavation Program and U.S. Army Corps of Engineers lower Pajaro River Flood Control Program) to ensure these programs incorporate appropriate steelhead habitat protection and restoration provisions.
- Collaboration with local, state, and federal agencies and non-governmental organization in the acquisition of fee-title to parcels or establishment of conservation easements over selected stream and riparian corridors to protect steelhead migratory, spawning, and rearing habitats.
- Physically modify passage barriers (including the dams and diversion facilities identified in Table 7-2 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 SCCCS DPS 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, 2, and 3 watersheds.
- Implement restoration projects to provide access to historical 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. Provide community education on the impacts of illegal take (including poaching) of wild steelhead and their progeny.
- 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 in Chapters 9-12).
- 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 appropriate management of public and private facilities releasing waste discharges (see Appendix F, Pesticide Application Best Management Practices).
- 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 CDFW, 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, instream flows, and establishment of properly functioning riparian buffers on seasonal and permanent streams 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.

Conduct research on the life history of naturalized population of non-native species such as striped bass in the Pajaro, Salinas, and Carmel Rivers. 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 CDFW 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 1259.4 dealing with instream flows to protect instream beneficial uses, including native fishes, to SCCCS Recovery Planning Area, with appropriate provisions to address regional differences, including but not limited to construction of off-stream storage as alternative to direct diversions during the dry season.
- Streamline permitting processes for categories of projects (*e.g.*, off-channel winter water storage to reduce summer water withdrawals, installation of large woody debris, removal of smaller fish passage impediments, *etc.*) to reduce costs and length of time to implement recovery actions

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 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 12. 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).

SCCCS DPS threats assessments were identified at a watershed scale, and do not necessarily identify site-specific threat sources in each reach of individual watersheds; therefore, 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, or should be updated). Some recovery actions may involve the review and modification of local general plans and local coastal plans (along with other regional plans) to promote activities to restore and protect steelhead habitats.

Implementation of many recovery actions will require site-specific investigations to determine 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 project alternatives, identify mitigation measures, and/ or require project monitoring, as part of the project permitting process.

Table 8-1. Recovery Actions Glossary.[1]

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. Restrict further development in these areas to protect *all O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation, and rearing, and their associated habitats. Plans should include incentives, including streamlining of applicable permitting processes, for agricultural related activities.
	Manage livestock grazing to maintain or restore aquatic habitat functions	Develop and implement a 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. Plans should include incentives for construction and management of off-stream water for livestock, including streamlining of applicable permitting processes.
	Manage agricultural development and restore riparian zones	Develop and implement a plan to manage agricultural development outside of the active floodplain (generally defined by 2-5 year frequency flood event) to create an effective riparian buffer; restore and re-vegetate a minimum riparian buffer. Include provisions for properly functioning riparian conditions to allow the channel to maintain natural structural diversity, and 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. Plans should include incentives for construction and management of off-stream water for livestock, including streamlining of applicable permitting processes.
Agricultural Effluents	Develop and implement plan to minimize runoff from agricultural activities	Develop and implement a plan to reduce or eliminate nutrient and pesticide/herbicide runoff and sediment inputs into watercourses from agricultural activities. Reduction of agricultural runoff will help to provide water quality suitable for all *O. mykiss* life history stages, including adult and juvenile migration, spawning, incubation and rearing habitat.

[1] The recovery actions are listed alphabetically here and in the recovery tables of Chapters 9-12 to aide consultation; the order is not intended to imply prioritization, which is indicated separately for each recovery action in individual watersheds identified in Chapters 9-12.

Threat Source	Recovery Action	Detailed Description
Culverts and Road Crossings (Passage Barriers)	Develop and implement plan to remove or modify fish passage barriers within the watershed	Develop and implement a 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 of development into the riparian corridor and restore sediment transport.
	Conduct watershed-wide fish passage barrier assessment	Conduct a watershed-wide fish passage barrier assessment between the ocean and all upstream spawning and rearing areas (including above known existing barriers in Core watersheds). A passage barrier assessment should use protocols identified in the CDFW'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 appropriate diversion rates for all surface water diversions to ensure maintenance of 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. Plans should include provisions for development of off-stream storage of winter flow for summer irrigation use in exchange for reduced summer diversions, including streamlining of applicable permitting processes.
	Develop and implement water management plan for dam operations	Develop and implement an operational plan to optimize 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.
	Provide fish passage around dams and diversions	Develop and implement a 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 a flood control maintenance program to minimize the frequency and intensity of disturbance to instream habitats and riparian vegetation (*e.g.*, modification of natural channel morphology and removal of native vegetation).
Groundwater Extraction	Conduct groundwater extraction analysis and assessment	Conduct hydrological analysis to identify groundwater extraction rates, effects to the natural pattern (timing, duration and magnitude) of surface flows in the mainstem, tributaries, and estuary, and effects on all *O. mykiss* life history stages, including

Threat Source	Recovery Action	Detailed Description
		adult and juvenile *O. mykiss* migration, spawning, incubation and rearing habitats.
	Develop and implement groundwater monitoring and management program	Develop and implement a 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 a 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. Focus initial efforts on high value habitats.
	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	Develop and implement a plan to vegetate levees with local native, wherever feasible, and eliminate or minimize the use of herbicides to control native vegetation adjacent to existing levees.
	Develop and implement stream bank and riparian corridor restoration plan	Develop and implement a stream bank and riparian corridor restoration plan to reduce channel incision, sedimentation from bank erosion, and reduce or eliminate the need for bank stabilization; wherever feasible, remove rip-rap and other artificial bank stabilization features on mainstems and tributaries. Replace these features with bio-engineered bank stabilization, or additional set-backs, to allow channels to maintain natural structural diversity.
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. Focus initial efforts on mining operation located within the bank full channel.
	Develop and implement plan to remove quarry and landslide debris from the channel	Develop and implement a 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.

Threat Source	Recovery Action	Detailed Description
Non-Native Species	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	Develop and implement a watershed-wide (or reach-specific) 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) where they are determined to be detrimental to riparian habitats. Restore riparian and adjacent 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 monitoring programs to track 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 potential 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 restoration and protection of creeks, rivers, estuaries, wetlands and riparian/floodplain areas, including an effective setback for all development adjacent to 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 a 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 life history stages, including adult and juvenile migration, spawning, incubation and rearing habitats.

Threat Source	Recovery Action	Detailed Description
Roads	Manage roadways and adjacent riparian corridor and restore abandoned roadways	Develop and implement a 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.
	Retrofit storm drains to filter runoff from roadways	Develop and implement a 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 a 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 an estuarine restoration and management plan. To the maximum extent feasible, a plan should include restoring the physical configuration, size and diversity of the wetland habitats, eliminate exotic species, control artificial breaching of the sand bar, and establish an effective buffer to restore estuarine functions and promote *O. mykiss* use 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, when applicable, 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 Integrated Natural Resources Management Plans (INRMP) and modify, where applicable, 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 urban 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.

Threat Source	Recovery Action	Detailed Description
	Retrofit storm drains in developed areas	Develop and implement plan to retrofit storm drains in developed 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.
	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 discharges are 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 Wildlife and U.S. Fish and Wildlife Service 2010, California Department of Fish and Wildlife 2004, California Department of Fish and Wildlife and National Marine Fisheries Service 2001). Potential sources of wild steelhead within the SCCCS Recovery Planning Area include the facility operated at Sleepy Hollow on the Carmel River, Monterey County, and the land-locked wild steelhead population above Whale rock Reservoir on Old Creek, San Luis Obispo County.

While a conservation hatchery program[2] can complement the overall recovery effort, the role of such a program does not substitute for the extensive restoration of habitat function, value, and connectivity that is required to abate the threats to SCCCS DPS.

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 SCCCS DPS 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 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, recovery of depleted (or extirpated) populations depends on one or more recolonization events, a process that operates on an unpredictable 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 restoration or increased

[2] 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.

availability of habitat is not sufficient to prevent extirpation populations from individual watersheds. (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 prevent immediate extirpation in order to attain self-sufficiency and sustainability in the wild.

There is considerable uncertainty regarding the ability of artificial propagation to increase 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 the long-term viability of a population when depending on artificial augmentation to maintain and/or increase population abundance. 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, 2003, 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 the growth rate in the overall population comprised of natural-origin and hatchery-origin spawners in the natural environment.

Spatial Structure. Small populations are at risk of local and regional extirpations because of ongoing habitat loss and fragmentation, as well as dysfunctional expression of species behavior which can undermine the species 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 help reestablish natural spatial population structure.

Diversity. To conserve the adaptive diversity of salmonid populations, the selective pressures which drove their evolution and the natural processes which select for population fitness should be allowed to continue. Conservation hatcheries can conserve valuable genes and genotypes, if properly 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 issues outlined above and could provide effective guidance in a conservation hatchery program to protect the currently depressed stocks and recover steelhead populations in 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 when 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 revision;

c) determine when the program should adapt to evolving recovery needs and

d) determine when the conservation hatchery program is no longer needed.

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

a) fish culture problems that arise within the program;

b) fish response to habitat, environmental challenges, pathogens, *etc*.;

c) factors which contribute to reduced fitness and reproductive success of hatchery fish in the natural environment; and

d) 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) Contain 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 and where 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. Additional considerations such as the location of a facility supported by a reliable water supply, and whether to use a regional facility versus small, local, and perhaps temporary facilities are also important.

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 attributes 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 genetic and phenotypic characteristics favoring survival in a spatially and temporally highly-variable environment. The inland populations (*e.g.*, Salinas, Arroyo Seco, Upper Salinas, Pajaro, Carmel, Arroyo Grande) extend over a broad and geographically diverse area, and are likely able to withstand environmental stochasticity and possess ecologically significant attributes not found in most other steelhead DPS 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 their ability to adapt in response to longer-term changes (*i.e.*, such as 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 which places the population at greater risk, particularly in stochastic environments. General guidelines or numerical values for N_e are specified in the literature for maintaining minimum N_e for individual populations (Meffe and Carroll 1997, Nielsen 1995, Glidden and Goudet 1994, Chesser *et al.* 1993, Crow and Kimura 1970), but may require further research specifically for populations of SCCCS DPS.

Population Viability. Whether a population is likely to be viable is another key consideration in determining the necessity 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.

For an example of guidelines for establishing a conservation hatchery program, see, California Department of Fish and Wildlife (2004) Recovery Strategy for Coho Salmon, Appendix H.

8.4 ESTIMATED TIME TO RECOVERY AND DELISTING

NMFS's interim recovery planning guidance (2010a) recommends 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 ten years) of completion of the Recovery Plan; and
- 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; and
- 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 of demographic targets which must be met to delist; and
- 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 these individual components can be estimated.

Completion of a majority of the recovery actions is estimated to vary from five to ten 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 these time frames would vary in a majority of cases to from 5 to 15 years, though the response of some habitats may take longer, depending on severity of damage, as well as rainfall and runoff patterns. The time for the species to respond to recovery actions is the most challenging component to estimate for a variety of reasons including; the dependency of anadromous runs and spawning and rearing success upon rainfall and runoff patterns. These patterns can be cyclic, and may also be significantly influenced by projected climate changes, and uncertainties regarding aspects of the demographics of SCCCS 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 BPGs in the 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 (north-to-south) of the SCCCS Recovery Planning Area and includes portions of Santa Clara, San Benito, Monterey, and San Luis Obispo Counties. This BPG 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 Salsipuedes, Corralitos, Casserly, San Benito River, Uvas, Pacheco and Llagas sub-watersheds. The Salinas River watershed is the largest coastal watershed contained entirely within California, 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, Nacimiento River, and Estrella 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 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 (see 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 higher elevations of the western portion of 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. As noted in Chapter 2, the San Benito River flows on the east side of the Gabilan Range, and is considerably drier, with sparse shading, and limited potential to provide over-summering habitat for rearing juvenile steelhead; similar conditions exist in the Estrella River, tributary to the upper Salinas River which joins the Salinas from the east.

Nacimiento River

Although the highly dissected topography contributes to a very large total stream length in this region (7,773 miles), the majority of drainages naturally exhibit seasonal surface flow or have extensive intermittent reaches because of the highly variable patterns of precipitation (influenced by an orographic effect as winter storms pass over the coastal ranges) and the complex geology (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Alt and Hyndman 2003, McCulloch 1990, Norris and Web 1990, Page 1981, Muir 1972).

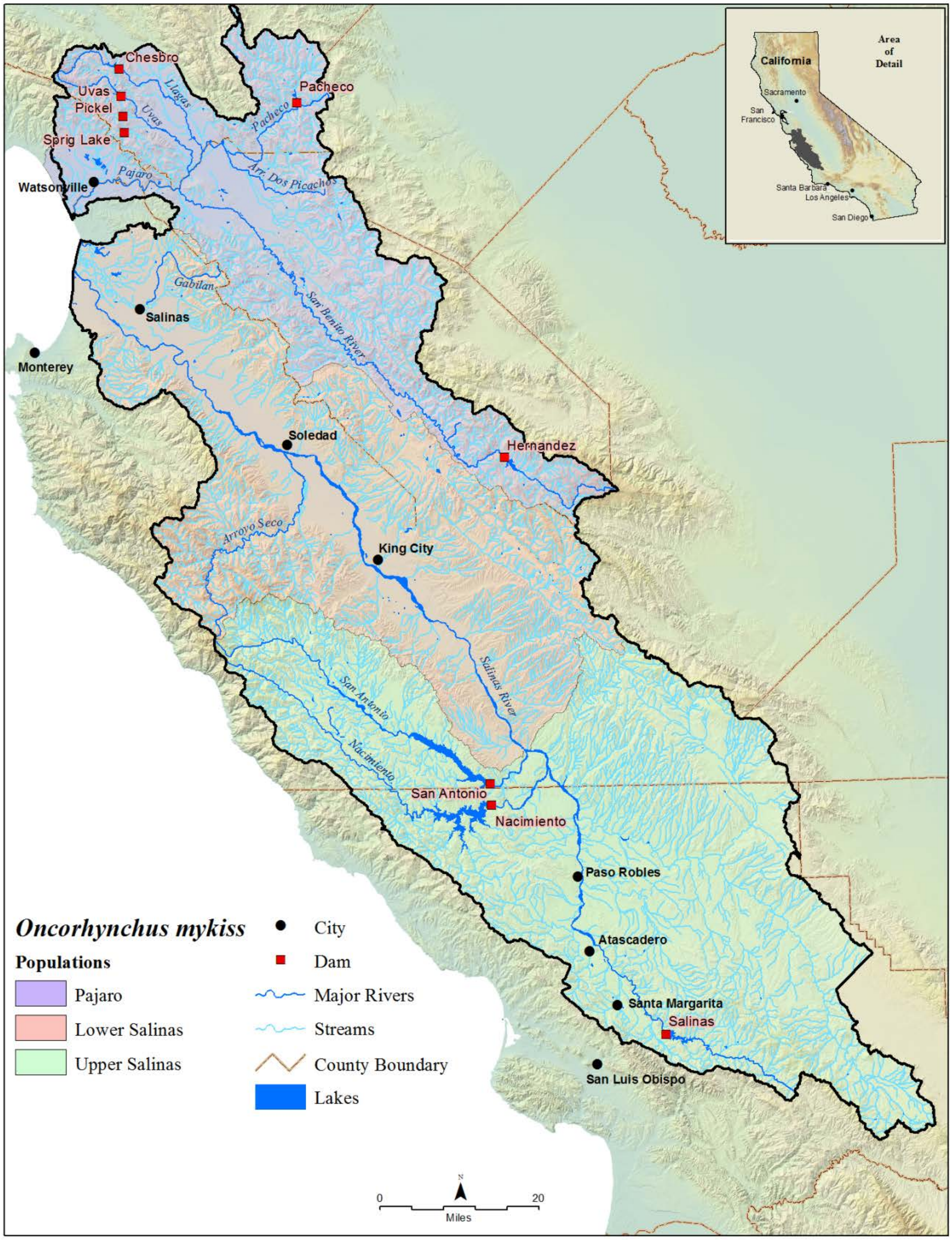

Figure 9-1. The Interior Coast Range BGP. Seven populations/watersheds were analyzed in this region: two in the Pajaro River watershed (mainstem Pajaro River and Uvas Creek); three in the Lower Salinas River watershed(mainstem Salinas, Gabilan Creek, Arroyo Seco), and two in the Upper Salinas River watershed (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. 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. However, non-governmental organizations such as The Nature Conservancy, the Land Trust of Santa Cruz County, the Big Sur Land Trust, and the Peninsula Open Space Trust have acquired significant lands within these watersheds. Public ownership of land is concentrated in the Los Padres National Forest and military bases, such as Fort Hunter-Liggett and Camp Roberts, located in the western portions of this BPG. 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. 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). See Figure 9-2 for the pattern of federal and non-federal land ownership within the Pajaro River watershed; and Figure 9-3 for the pattern of federal and non-federal landownership within the Salinas River watershed.

Confluence of Arroyo Seco and Salinas River – Agricultural Development

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, (though Sprig and Pickel Dams no longer impound water or block fish passage). These dams are owned and operated by, state, public utility, local government, or private interests for irrigation, flood control and stormwater management, recreation, municipal water supply, hydroelectric power generation, fire protection, farm ponds, or a combination of these purposes (California Department of Fish and Wildlife 2012a, 2012b, 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 (Pajaro River watershed), San Antonio, Nacimiento, and Salinas (Salinas River watershed) do not provide upstream fish passage, though may inadvertently allow downstream fish migration from areas above the reservoirs (which act as a refugia for non-native warm water species). Additionally, there is a large seasonal dam and diversion structure on the lower Salinas River which is designed to impound and distribute spring, summer, and early fall releases from the upstream reservoirs to provide surface water deliveries for nearby agriculture; these surface water diversions are intended to offset groundwater pumping and therefore reduce saltwater intrusion into the coastal groundwater basin. The operation of this facility is governed by a Biological Opinion issued by the NMFS which describes the standards, criteria, and timing for that are necessary for the completion of the steelhead's life-cycle within the Salinas watershed (National Marine Fisheries Service 2007c). Several of the smaller dams such as Sprig and Pickel 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.

Salinas River - Rock Quarry Operation

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, Bodensteiner *et al.* 2003; see also Monterey County Water Resources Agency 2010a, 2010b, 2011a, and 2011b).

Table 9-1. Physical and Land Use Characteristics of Watersheds in the Interior Coast Range BPG. Sub-watersheds are 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), Cal Fire 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)*

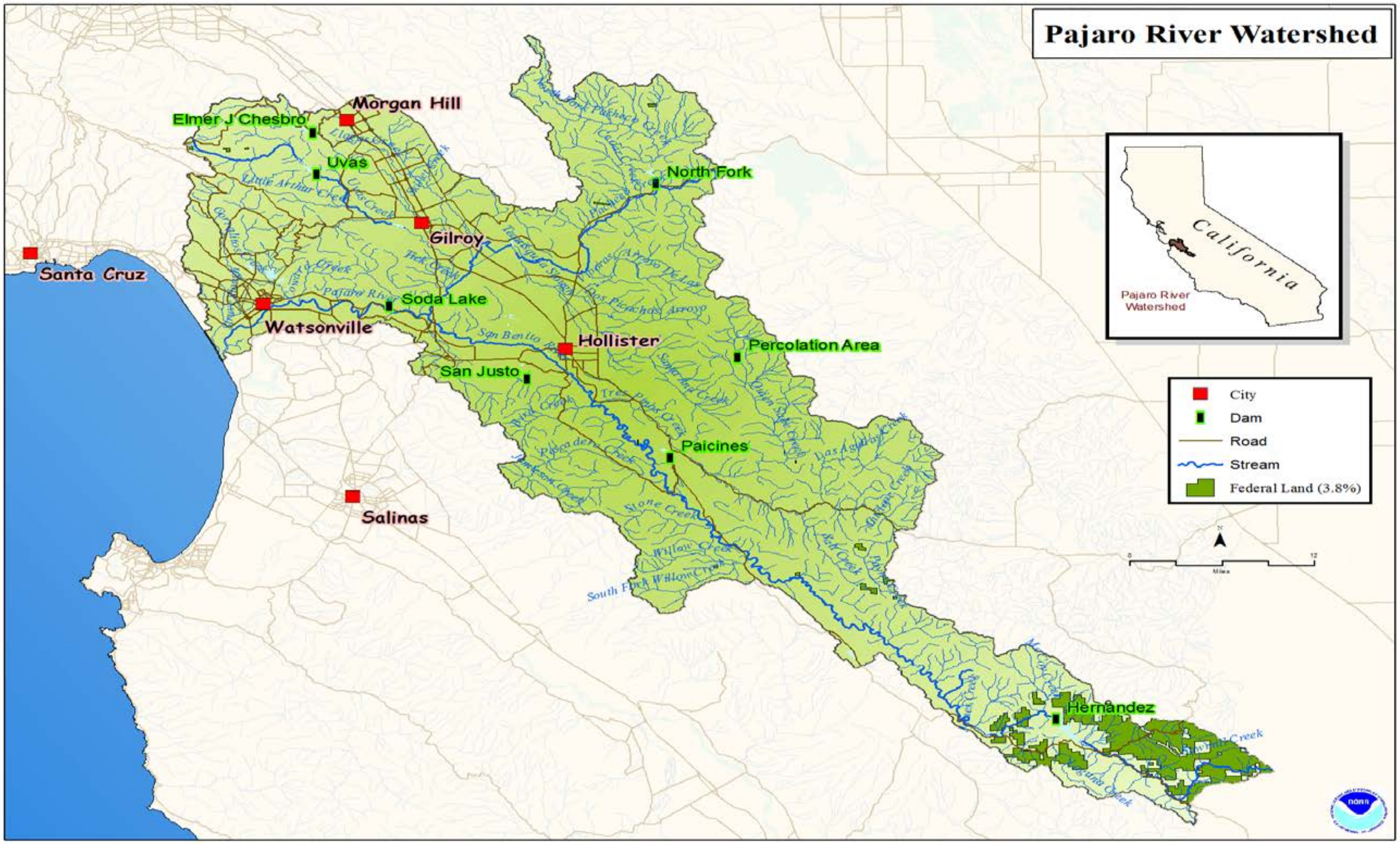

Figure 9-2. Federal and Non-Federal Land Ownership within the Pajaro River Watershed.

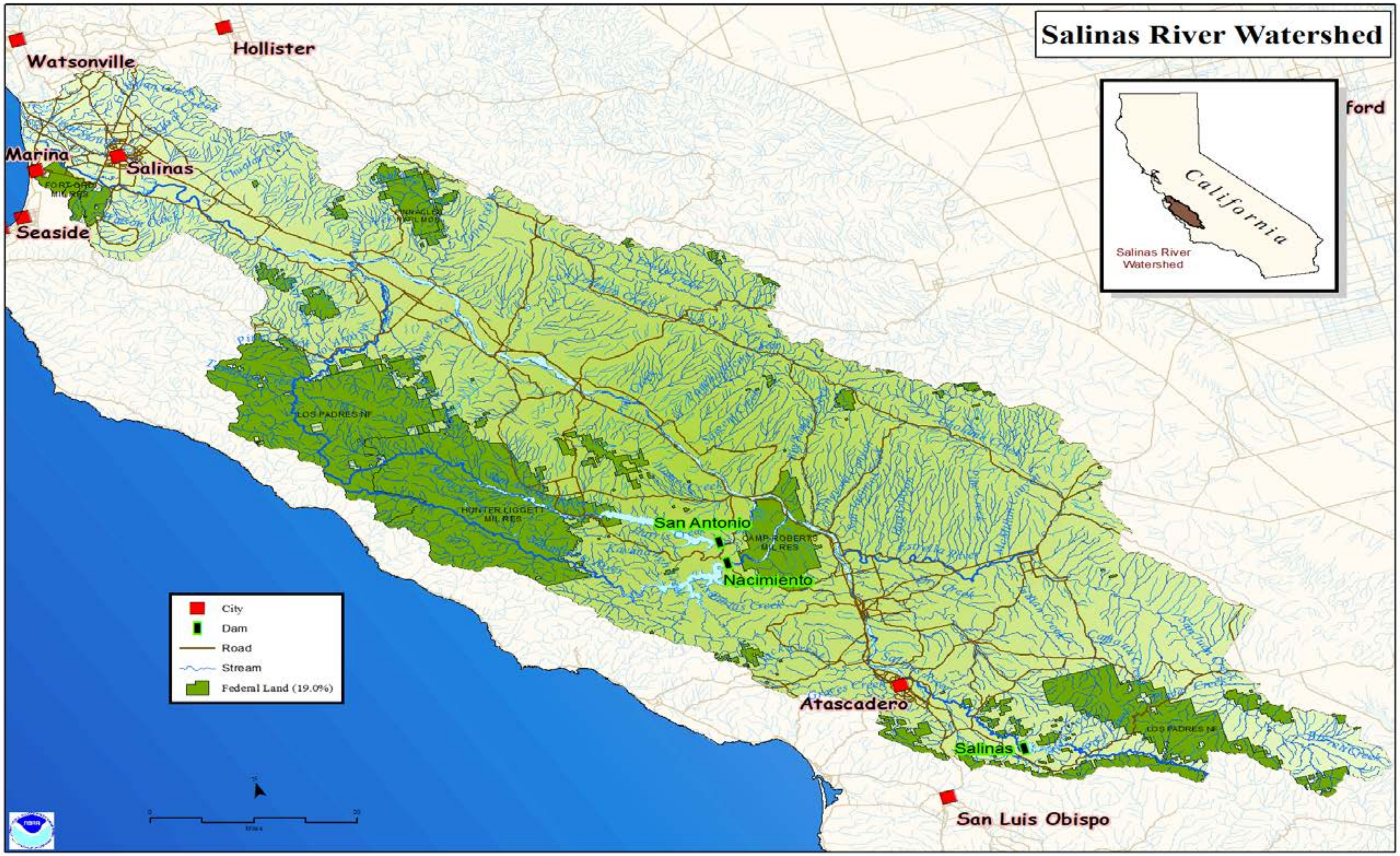

Figure 9-3. Federal and Non-Federal Land Ownership within the Salinas River Watershed.

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 chosen from those identified by the TRT, with the focus on conditions most directly relevant to steelhead. The mainstem and major tributaries of most of the drainages in this BPG currently provides fair to poor habitat conditions for anadromous *O. mykiss*. Habitat conditions were rated as "Fair" in the Uvas 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, Smith 2013, 2007a, 2007b, 1998, 1992, Casagrande 2012, 2011, 2010a, 2010b, 2010c, 2003, 2001, Central Coast Salmon Enhancement 2008, Santa Clara Valley Water District 2007, 2006, Unites States Army 2007, Harris *et al*. 2006, Casagrande and Watson 2006, San Benito County Water District 2006, **C**asagrande and Hager 2003, Upper Salinas-Las Tablas Resource Conservation District 2004, Hagar Environmental Science 2001, Hager 2001, Londquist 2001, Stephenson and Calcarone 1999, Harvey & Stanley Associates 1983). 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 heavily restricted by downstream fish passage barriers (Casagrande 2010b).

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.

Uvas Creek – Pajaro River Tributary

A major concern in this BPG is that the mainstems of the two primary drainages, the Pajaro and Salinas rivers, are severely impaired by intensive anthropogenic activities related to agriculture, and residential development and associated water development and management (see discussion below). Additionally, historic logging in the upper watershed of the Pajaro

River has created on-going legacy effects as a result of the removal of old growth forests, and associated roads. This threat is being addressed through a variety of programs sponsored by the County of Santa Cruz, including the Integrated Watershed Restoration Program for Santa Cruz County. The County also has a Large Woody Material Program, though this does not specifically address legacy effects.

The mainstems of these rivers are critically important because 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

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 mainstem of 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. As noted above, reservoirs associated with these dams also act as refugia for non-native warm water species. (see discussion on the importance of restoring flow regimes in section 7-5 above).

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 (*e.g*., in the lower Pajaro and Salinas Rivers), and degraded water quality through the elevation of fine sediments and the application of agricultural pesticides and fertilizers. Instream gravel mining operations in both the Pajaro and Salinas River watersheds have also contributed to degraded habitat conditions, particularly mainstem habitats. Gravel mining can increase turbidity, reduces habitat complexity, and impedes sediment transport (Cluer 2004).

Pajaro River Estuary

Estuarine habitat loss (including both areal extent and habitat functions) 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 90%. Both the Salinas and Pajaro River Estuaries presently provide potential rearing habitat for juvenile steelhead in the wind-mixed western portion of the Salinas River Estuary, and normally tidally influenced downstream portion of the Pajaro River Estuary (Smith 2013, 2007a, 1992). Estuaries can provide favorable rearing habitats for juvenile *O. mykiss*, and have been shown in some cases to provide a disproportionate number of the returning anadromous adult *O. mykiss* in some systems (Hayes *et al*. 2012, 2011, 2008, Bond 2006). However, rearing young-of the-year or other smaller juveniles do not have ready access to these estuaries because of the great distances between the estuaries and the upstream spawning areas (40+ miles in the Arroyo Seco on the Salinas River) and the low or interrupted flows in the lower main stems of the Salinas and Pajaro Rivers. Nevertheless, severe estuarine losses and decline of estuarine functions can affect anadromous *O. mykiss* populations in widely separated tributaries of the Salinas River, such as Arroyo Seco and the San Antonio and Nacimiento Rivers. Research on these estuaries, in particular steelhead use of the estuary for rearing, would increase the understanding of the role of estuaries in the life history of these populations, and facilitate the management of the estuaries (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 is relatively low compared to other BPGs (*e.g.*, the Big Sur Coast BPG to the south). Wildland fires are not 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 burned a significant portion of the Corralitos, Browns Valley, and upper Uvas Creek sub-watersheds within the Pajaro River system. Additionally, wildfires pose a 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 changes to substrate composition and embeddedness, water quality (*e.g.*, turbidity), and water temperature increases through loss of riparian habitat (Varkaik *et al.* 2013, Keeley *et al.* 2012).

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 low 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.

9.4 THREATS AND THREAT SOURCES

Habitat impairments (sources of threats) identified in the CAP Workbooks for the Interior Coast Range BPG, ranged 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 Workbooks has also been incorporated into the threat assessment. The level of threat is generally very high in all watersheds in this BPG, including major tributaries such as Uvas and Gabilan Creeks and along the mainstem Pajaro and Salinas Rivers (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b; see also, Smith 2013, 2007a, 2007b, 2007c, 1982, Casagrande 2013, 2011, 2003, 2001, California Department of Fish and Wildlife 2012a, 2012b, Central Coast Salmon Enhancement 2008, Casagrande and Watson 2006, San Benito County Water District 2006, Santa Clara Valley Water District 2006, Hagar Environmental Science 2005a, 2005b, 2001, Monterey County Water Resources Agency 2005, Upper Salinas-Las Tables Resource Conservation District 2004, Casagrande *et al*. 2003, Hager 2001, Londquist 2001, Watson *et al.* 2000, Stephenson and Calcarone 1999, Sundermeyer 1999, Harvey & Stanley 1983; see also, Cuthbert *et al.* 2011b, 2011a, and 2010).

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, including dam operations, diversions, and groundwater extractions (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

As noted above, historic logging in the upper watershed of the Pajaro River has created on-going legacy effects as a result of the removal of old growth forests, and associated roads. Other watershed developments, including agricultural developments have increased erosion and sedimentation, particularly in the lower mainstem of the Pajaro River and Salinas Rivers, and within some tributaries, has contributed to habitat degradation, particularly of spawning and rearing habitats (see for example, Monterey County Agricultural Commissioner's Office 2011, Monterey Bay National Marine Sanctuary Advisory Council 2008, 2003).

Exotic fish species, including, but not limited to, striped bass (*Marone saxatilis*), has the potential to prey upon and compete with *O. mykiss* and require further monitoring and evaluation of their impacts on steelhead and steelhead habitat (Casagrande 2011). The spread of other exotic and invasive species, including plant species, also continues to increase with the increasing human population and related changes in land uses within the Interior Coast Range BPG; for example, Giant Reed (*Arundo donax*) in *watersheds such as Salinas River has become* more extensive and potentially invasive in other watersheds within the Interior Coast BPG. The early detection, rapid response to, and preferably prevention of, these introductions is an important component in any comprehensive steelhead recovery effort within the Interior Coast Range BPG.

The periodic artificial breaching of the sandbars at the mouths of the Pajaro and Salinas Rivers is also a potential threat to rearing juvenile steelhead in these estuaries, and must be managed in conjunction with upstream flow to ensure the rearing functions of these estuaries is maintained, and the migration of both adult and juvenile steelhead is not adversely affected (National Marine Fisheries Service 2009b; see also Seghesio 2011, Behrens 2008, Gladstone *et al*. 2006, Stretch and Parkinson 2006, Martin 1995, Kjerfve 1994, Thorpe 1994, Smith 1990).

See Figure 9-5 for an overview of the dams and other fish passage impediments within the SCCCS DPS, but note that not all of the dams currently impede fish migration, either because they are seasonally operated to allow fish passage (*e.g.,* Sprig Lake and Pickel Dam within the Pajaro River watershed), or have fish passage facilities. Also, the status of fish passage impediments is in constant flux, with old impediments being removed or modified, while new impediments may be installed, or discovered through updated inventories; a current list of priority fish passage impediments can be found on the California Department of Fish and Game Website:
http://www.cafishpassageforum.org/

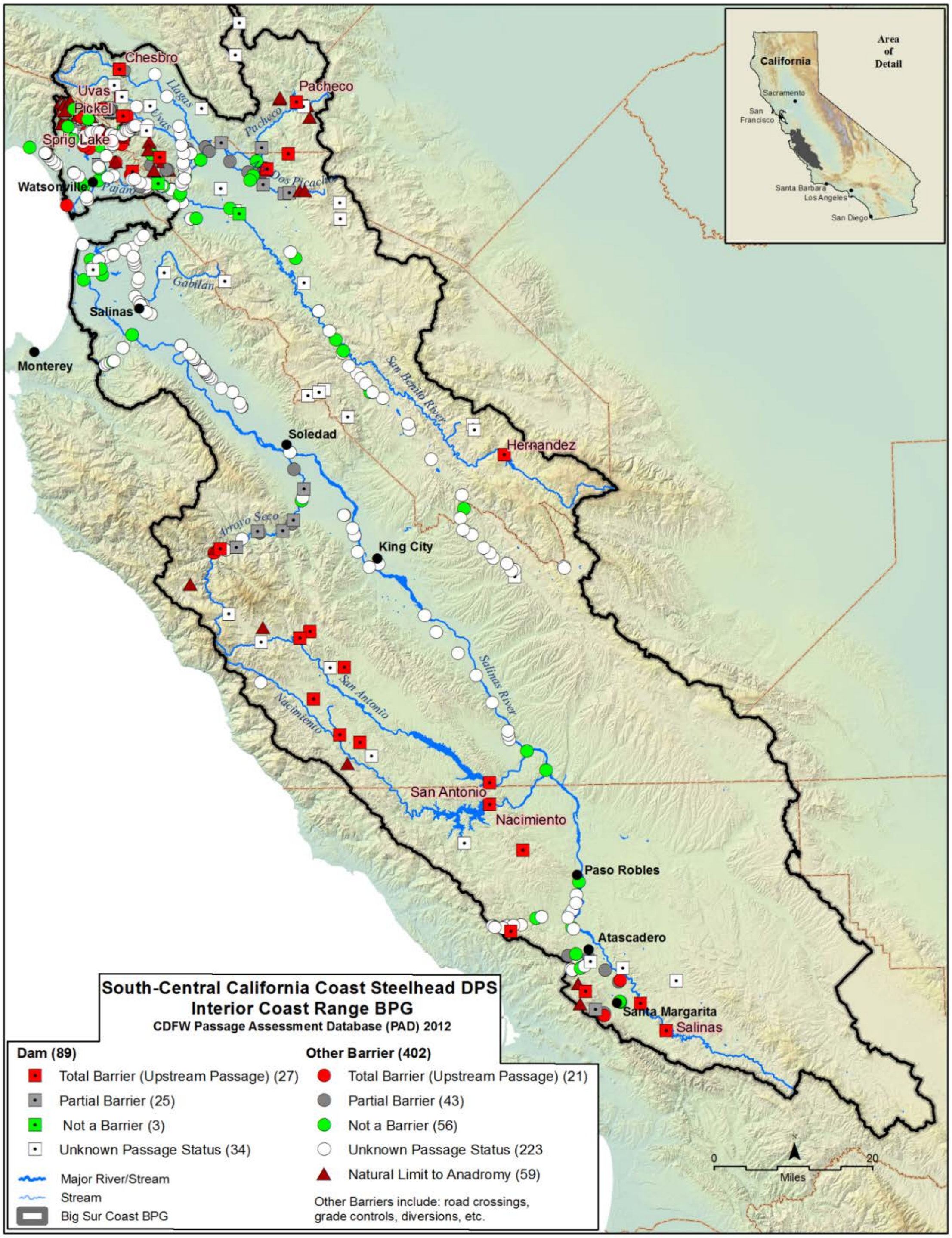

Figure 9-4. Major Fish Passage Impediments, Interior Coast Range BPG. Note: the status of fish passage impediments is in flux, with existing ones being removed or modified, while new ones may be installed, or discovered through updated inventories; a current list of priority fish passage impediments can be found on the California Department of Fish and Wildlife website: http://www.cafishpassageforum.org/

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

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

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 and Salinas Valleys, 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 these important steelhead-bearing watersheds. Numerous small fish passage barriers have also cumulatively impacted the Pajaro River system by preventing or impeding 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, and prioritizes those actions within each watershed.

Restoring conditions for steelhead passage, spawning, and/or rearing in these watersheds will require multiple, long-term measures related to water management 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 and Salinas Rivers), 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 reduced freshwater inflow, filling, and pollution from point and non-point agricultural and other anthropogenic waste discharges need to be addressed further in the Salinas and Pajaro River Estuaries.

Uvas Creek (Pajaro River) Fish Rescue Volunteer - 2012

The threats sources discussed in this section should be the focus of a variety of recovery actions to address specific threats to the viability of anadromous *O. mykiss* populations. 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 recovery actions or to target additional recovery actions as part of any recovery strategy for the Interior Coast Range BPG.

Management of the steelhead populations of the Interior Coast Range BPG will also require additional investigations of the population structure of the BPG; these studies should include, but not be limited to, the role of the various individual watersheds and sub-watersheds, in the maintenance of the BPG as a whole; how these individual populations contribute to the diversity of the BPG; the role of the non-anadromous fraction of the *O. mykiss* populations in the maintenance of the steelhead populations, and the role and use of the estuaries by steelhead, particularly rearing juveniles.

Table 9-3 below highlights critical Recovery Actions recovery actions for the Carmel River Basin BPG. The following Tables 9-4 through 9-6 identify a full suite of recovery actions necessary to recover these populations and describe and prioritize recovery actions for each sub-watershed in the Interior Coast Range BPG. These tables also provide provisional cost estimates 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	Develop and implement operating criteria to ensure the pattern and magnitude 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 passage impediments (*e.g.*, 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, and restoration of spawning gravel recruitment to the lower mainstem (*e.g.,* Uvas Creek). Manage instream mining to minimize impacts to migration, spawning, and rearing habitat, and protect spawning and rearing habitat in major tributaries, including Uvas, Corralitos, Llagas, and Pacheco Creeks, and the San Benito River. Identify, protect, and where necessary, restore estuarine rearing habitats, including management of artificial breaching of the sandbar at the river's mouth.
Salinas River	Develop and 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, and protect spawning and rearing habitat in major tributaries, including the Arroyo Seco. Identify, protect, and where necessary, restore estuarine rearing habitats, including management of artificial breaching of the sandbar at the river's mouth.
Arroyo Seco River	Develop and Implement operating criteria to ensure the pattern and magnitude of groundwater extractions from the Arroyo Seco and lower Salinas River provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Physically modify fish passage impediments, including concrete road crossing and diversion structure 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	Develop and 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	Develop and implement operating criteria to ensure the pattern and magnitude of water 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 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.

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, Chapter 6, Section 6.4, for a discussion of Recovery Action Ranks, and Chapter 3, Section 3.0, for a description of Listing Factors. See Appendix E for a discussion of recovery action cost estimates.

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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, SCCRCD, 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, SCCRCD, 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, SCCRCD, 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, SCCRCD, 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 (or review and up-date, *e.g.,* County of Santa Cruz Crossing Inventory and Fish Passage Evaluation)	NMFS, USFS, CDFW, RCDMC, SCCRCD,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

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-3.2	Develop and implement a plan to remove or modify fish passage barriers within the watershed	NMFS, SCRC, MC, RCDMC, SCCRCD, COG, COW, CDFW, CDOT, TWI, CT, TU, CHEER	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
Paj-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFW, 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 (*e.g.*, Uvas Dam, College Lake)	NMFS, CDFW, 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, CDFW, SWRCB, SCRC, RCDMC, SCCRCD, 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, CDFW, 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 (or review and update)	USGS, NMFS, CDFW, 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 (or review and update)	USGS, NMFS, CDFW, SCRC, SCVWD, TWI, TU, CT, CHEER	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
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, SCCRCD, SCVWD, NMFS, CDFW, 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 channel features	CSCC, NMFS, CDFW, SCRC, MC, RCDMC, SCCRCD, SCVWD, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500
Paj-SCCCS-7.3	Develop and implement a stream bank and riparian corridor restoration plan	CSCC, NMFS, CDFW, SCRC, MC, RCDMC, SCCRCD, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
Paj-SCCCS-8.1	Review and modify mining operations (*e.g.,* using guidance in Cluer 2004)	NMFS, CDFW, SCRC, MC, RCDMC, TWI, TU, CT, CHEER	Mining and Quarrying	1, 4	1B	20	68030	0	0	0	0	68030
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, CDFW, NRCS, RCDMC, SCCRCD, TWI, TU, CT, CHEER	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
Paj-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, NMFS, CDFW, NRCS, RCDM, SCCRCD, 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, CDFW, NRCS, RCDMC, SCCRCD, 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, BLM, CSCC, CDFW, CDPR, TU, CT, CHEER	Recreational Facilities	1, 2, 3, 4, 5	3B	20	0	0	0	0	0	0
Paj-SCCCS-10.2	Develop and implement public education program on watershed processes	USFWS, CSCC, CDFW, SCRC, SCCRCD,TWI, TU, CT, CHEER	Recreational Facilities	1, 2, 3, 4, 5	3B	20	76140	76140	76140	76140	0	304560
Paj-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, USFWS, CSCC, CDFW, SCRC, 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, CDFW, 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, CDFW, SCRC, 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, CDFW, SCRC, TU, CT, CHEER	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	8174000	0	0	0	0	8174000

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-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCOM, CDFW, 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, CDFW, 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, CDFW, 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 replace artificial bank stabilization structures	ACOE, NRCS, NMFS, RCDMC, SCRC, MC, CDFW, TU, CT, CHEER	Urban Development	1, 4	2B	5	398000	0	0	0	0	398000
Paj-SCCCS-14.1	Review California Regional Water Quality Control Board Region Basin Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, NRCS, NMFS, CDFW, 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, CDFW, 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, CDFW, USGS, SB, SCC, SCRC, RCDSC, BCLC, 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, CDFW, USGS, SBCC, SCRC, RSDSC, BCLC, 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, CDFW, USGS, SCC, SCRC, RSDSC, BCLC, 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, CDFW, USGS, SCC, SCRC, RSDSC, BCLC, 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, CDFW, SCRC, RSDSC, CDOT, BCLC, 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, CDFW, SCRC, BCLC, 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 for diversion	NMFS, CDFW, SWRCB, SCRC, RSDSC, BCLC, TWI, ACWA, CT, TU, CHEER	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
	operations											
UC-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, CDFW, SWRCB, SCRC, RSDSC, BCLC, 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, CDFW, SWRCB, SCRC, RSDSC, BCLC, 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, CDFW, 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 (or review and update)	USGS, NMFS, CDFW, SCRC, RSDSC, BCLC, 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 (or review and update)	USGS, NMFS, CDFW, SCRC, RSDSC, BCLC, 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, CDFW, BCLC, TWI, TU, CT, CHEER	Levees and Channelizatio n	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500
UC-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or	FEMA, CSCC, NMFS, CDFW, SCRC, RSDSC, TWI, TU, CT, CHEER	Levees and Channelizatio n	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											
UC-SCCCS-7.3	Develop and implement stream bank and riparian corridor restoration plan	FEMA, CSCC, NMFS, CDFW, SCRC, RSDSC, BCLC, 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, CDFW, SCRC, RSDSC, NRCS, BCLC, 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, CDFW, SCRC, RSDSC, NRCS, BCLC,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, CDFW, SCRC, RSDSC, NRCS, BCLC, 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, CDFW, CCRP, SCRC, WCB,TWI, TU, CT, CHEER	Recreational Facilities	1, 3, 5	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
UC-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, CSCC, CDFW, CCRP, BCLC, 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, CDFW, BCLC, 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, CDFW, BCLC, TWI, TU, CT, CHEER	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
UC-SCCCS11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	DOT, CDOT, USFWS, SCRC, CDFW, 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, CDFW, 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, CDFW,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, CDFW, TU, CT, CHEER	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
UC-SCCCS-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	SCRC, ACOE, NRCS, NMFS, SCRC, CDFW, BCLC, 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, CDFW, 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, CDFW, 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 and 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, RCDSC, MC, SLOC, NMFS, CDFW, 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, RCDMC, MC, SLOC, NMFS, CDFW, USLTRCD, 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, RCDMC, MC, SLOC, NMFS, CDFW, USLTRCD, 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, CDFW, RCDMC, MC,SLOC, USLTRCD, 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, CDFW, CCCON, MC, FRGP, SLOC, RCDSC, CDOT, USCW, USLTRCD,TWI, CT, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
Sal-SCCCS -3.2	Develop and implement a plan to remove or modify fish passage barriers with in the watershed	NMFS, CDFW, 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

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 -4.1	Develop and implement water management plan for dam operations	NMFS, CDFW, CCON, MC, MCWRA, FRGP, SLOC, RCDMC, 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, CDFW, CCON, MC, MCWRA, FRGP, SLOC, RCDMC, 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, CDFW, CCON, MC, MCWRA,FRGP, SLOC, RCDMC, USWC, USLTRCD,TWI, CT, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	10	TBD	TBD	TBD	TBD	TBD	TBD
Sal-SCCCS -5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, USGS, MC, SLOC, RCDMC, CDFW, 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 (or review and update)	USGS, NMFS, CDFW, MC, SLOC, RCDMC, 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 management program (or review and update)	USGS, NMFS, CDFW, MC, SLOC, RCDMC, USLTRDC, USWC,TWI, TU, CT, TCFT	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
Sal-SCCCS -7.1	Develop and implement a plan to restore natural channel features	FEMA, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RSDMC, CDFW, TWI, USLTRCD, USWC,CT, TU, TCFT	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
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, RCDMC, CDFW, 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, RCDMC, CDFW, 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 (*e.g.,* using guidance in Cluer 2004)	USGS, NMFS, CDFW, CDMG, MC, SLOC, NRCS, RCDMC, 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, CDFW, SCRC, RSDSC, NRCS, RCDMC, USLTRCD, USWC, TWI, TU, CT, TCFT	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
Sal-SCCCS -9.2	Develop and implement a non-native species monitoring program	USFWS, NMFS, CDFW, 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, CDFW, SCRC, RSDSC, NRCS, RCDMC, USLTRCD, USWC, TWI, TU, CT, TCFT	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
Sal-SCCCS-10.1	Manage off-road recreational vehicle activity in riparian floodplain corridors	USFWS, USFS, BLM, CDFW, 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, CDFW, 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, CDFW, 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-11.1	Management roadways and adjacent riparian corridor and restore abandoned roadways	DOT, CDOT, USFWS, MC, SLOC, CDFW, USLTRCD, USWC, TWI, TU, CT, TCFT	Roads	1, 4	2B	20	0	0	0	0	0	0
Sal-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	DOT, CDOT, USFWS, RWQCB, MC, SLOC, CDFW, 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, CDFW, USLTRCD, USWC, TWI, TU, CT, TCFT	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
Sal-SCCCS -12.1	Develop and implement a restoration an estuary restoration and management plan	USFWS, EPA, NMFS, NFWF, CDFW, 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, CDFW, 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, CDFW, 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 areas	RWQCB, NMFS, CDFW, MC, SLOC, USLTRCD, USWC, TU, CT, TCFT	Urban Development	1, 4	1B	20	0	0	0	0	0	0
Sal-SCCCS -14.1	Review California Regional Water Quality Control Boards Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, NMFS, MC, SLOC, CDFW, 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 ($K)					
							FY 1-5	FY 6-10	FY 11-15	FY 16-20	FY 21-25	FY 1-100
Sal-SCCCS -14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits (*e.g.,* City of Paso Robles Wastewater Treatment Facility)	RWQCB, SWRCB, NMFS, MC, SLOC, CDFW, USLTRCD, USWC, TU, CT, TCFT	Urban Effluents	1, 4	1B	20	0	0	0	0	0	0
Action #	**Recovery Action Description**	**Potential Collaborators**	**Threat Source**	**Listing Factors (1 - 5)**	**Action Rank (1A, 1B, 2A, 2B, 3A, 3B)**	**Task Duration**	**Fiscal Year Costs ($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, CDFW, 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, CDFW, 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, CDFW, 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	NRCS, BLM, NMFS, RWQCB, SWRCB, CDFW, USGS, SCC, , RSDSC, SCRC, TWI, TU,	Agricultural Effluents	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
	activities	CT, CHEER										
GC-SCCCS -3.1	Conduct a watershed-wide fish passage barrier assessment (or periodically up-date)	NMFS, USFS, CDFW, 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, CDFW, SCRC, RSDSC, CDOT, TWI, CT, TU, CHEER	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	0	0	0	0	0	0
GC-SCCCS -4.1	Develop and implement water management plan for any future diversion operations	NMFS, CDFW, 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, CDFW, 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, CDFW, 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, CDFW, 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, CDFW, SCRC, RSDSC, TWI, TU, CT, CHEER	Groundwater Extraction	1, 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
	(or review and update)											
GC-SCCCS -6.2	Develop and implement a groundwater monitoring and management program (or review and update)	USGS, NMFS, CDFW, 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, CDFW 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 levees	FEMA, USGS, NMFS, CDFW, ACOE, BLM, NRCS, SCRC, RSDSC, TWI, TU, CT, CHEER	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
GC-SCCCS -7.3	Develop and implement stream bank and riparian corridor restoration plan	FEMA, USGS, NMFS, CDFW, 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, CDFW, 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, CDFW, SCRC, RSDSC, NRCS, TWI, TU, CT, CHEER	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
GC-SCCCS	Develop and implement a public	USFWS, NMFS, CDFW, SCRC, RSDSC, NRCS,	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
-9.3	educational program on non-native species impacts (or periodically update)	TWI, TU, CT, CHEER										
GC-SCCCS -10.1	Develop and implement a public educational program on watershed processes (or periodically update)	USFWS, CSCC, CDFW, 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, CDFW, 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, CDFW, TWI, TU, CT, CHEER	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
GC-SCCCS -11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	DOT, CDOT,USFWS, SCRC, CDFW, 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, CDFW, 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, CDFW, TU, CT, CHEER	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
GC-SCCCS -14.1	Review California Regional Water Quality Control Boards Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, NRCS, SCRC, NMFS, CDFW, 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, CDFW, 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, CDFW, USTRCD, TWI, SVFFC, 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, CDFW, TWI, SVFFC,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, CDFW, TWI, SVFFC, 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	NRCS, BLM, USGS, RCDMC, RWQCB, SWRCB,MC, SLOC,	Agricultural Effluents	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
	agricultural activities	NMFS, CDFW, TWI, SVFFC, TU, ASRA										
AS-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment (or review and update)	NMFS, USFS, USFWS, CDFW, CCCON, MC, FRGP, RCDMC, CDOT, TWI, CT, SVFFC, 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, CDFW, CCCON, MC, FRGP, RCDMC, CDOT, TWI, CT, SVFFC, 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, CDFW, CCON, MC, MCWRA, FRGP, RSDMC, TWI, CT, SVFFC, TU, ASRA	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
AS-SCCCS-4.2	Develop and implement water management plan for any future diversion operations	NMFS, USFS, USFWS, CDFW, CCON, MC, MCWRA, FRGP, RCDMC, TWI, CT, SVFFC, TU, ASRA	Dams and Surface Water Diversions	1, 3, 4	1A	100	0	0	0	0	0	0
AS-SCCCS-4.3	Provide fish passage around any future dams and diversions	NMFS, CDFW, CCON, MC, MCWRA, FRGP, RCDSC, TWI, CT, SVFFC, 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, CDFW, NRCS, USGS, MC, RCDMC, CDFW, TWI, CT, SVFFC, TU, ASRA	Flood Control Maintenance	1, 4	3B	100	0	0	0	0	0	0
AS-SCCCS-6.1	Conduct groundwater extraction analysis	USGS, NMFS, CDFW, MC, RCDMC, TWI, SVFFC, TU, CT, ASRA	Groundwater Extraction	1, 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
	and assessment (or review and update)											
AS-SCCCS-6.2	Develop and implement a groundwater monitoring and management program (or review and update)	USGS, NMFS, CDFW, 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, CDFW, TWI, CT, SVFFC, TU, ASRA	Levees and Channelization	1, 4	2B	20	4217625	4217625	4217625	4217625	0	16870500
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, CDFW, TWI, CT, SVFFC, 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, CDFW, TWI, CT, SVFFC, 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, CDFW, RSDMC, NRCS, RCDMC, TWI, SVFFC, 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, CDFW, RCDMC, NRCS, RSDMC, TWI, SVFFC, TU, CT, ASRA	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
AS-SCCCS-	Develop and implement a public	USFWS, USFS, NMFS, CDFW, RCDMC, NRCS,	Non-Native Species	1, 3, 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 21-25	FY 1-100
9.3	educational program on non-native species impacts	RCDSC, TWI, SVFFC, TU, CT, ASRA										
AS-SCCCS-10.1	Manage off-road recreational vehicle activity in riparian floodplain corridors	USFWS, USFS, BLM, CDFW, MC, WCB, TWI, SVFFC, 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, CDFW, MC, WCB,TWI, TU, CT, ASRA	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
AS-SCCCS-10.3	Develop and implement a public educational program on watershed processes	USFWS, USFS, BLM, CDFW, MC, WCB, TWI, SVFFC, 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, CDFW, TWI, SVFFC, 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, CDFW, TWI, SVFFC, 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, CDFW, MC, SVFFC, 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	USFS, NMFS, RCDSC, RWQCB, SWRCB, CDFW, MC, SVFFC, TU, CT, ASRA	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
	stormwater permits											
AS-SCCCS-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	USFS, NMFS, RCDMC, RWQCB, SWRCB, CDFW, 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 and 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, CDFW, TWI, SVFFC, 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, CDFW, TWI, SVFFC, 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, CDFW, TWI SVFFC,,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, CDFW, TWI SVFFC,,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, CDFW, 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, CDFW, CCCON, MC, SLOC, FRGP, RCDMC, CDOT, TWI, CT, SVFFC, TU, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1B	5	96690	0	0	0	0	96690
SAnt-SCCCS-4.1	Develop and implement water management plan for diversion	NMFS, USFS, USFWS, CDFW, CCON, MC, SLOC, MCWRA, FRGP, RCDMC, TWI, CT, SVFFC, TU,	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
	operations	TCFT										
SAnt-SCCCS-4.2	Develop and implement water management plan for dam operations (or periodically update)	NMFS, USFS, USFWS, CDFW, CCON, MC, SLOC, MCWRA, FRGP, RCDMC, TWI, CT, SVFFC, 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, CDFW, CCON, MC, SLOC, MCWRA, FRGP, RCDMC, TWI, CT, SVFFC, 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, CDFW, NRCS, USGS, MC, RCDMC, CDFW, TWI, CT, SVFFC, 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 (or review and update)	USGS, NMFS, DWR, CDFW, MC, RCDMC, TWI, SVFFC, 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 (or review and update)	USGS, NMFS, DWR, CDFW, 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, CDFW, TWI, CT, SVFFC, TU, TCFT	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
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, CDFW, TWI, CT, SVFFC, 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, CDFW, 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, CDFW, MC, SLOC, RCDMC, MCWRA, NRCS, TWI, SVFFC, 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, CDFW, 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, CDFW, MC, MCWRA, WCB.TWI, SVFFC, 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, CDFW, MC, MCWRA, WCB.TWI, SVFFC, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
SAnt-SCCCS-10.3	Develop and implement a public educational program on watershed	USFWS, USFS, USA, BLM, NMFS, CDFW, MC, MCWRA, WCB.TWI, SVFFC, TU, CT, TCFT	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 21-25	FY 1-100
	processes											
SAnt-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, USA, CDOT, USFWS, MC, SLOC, MCWRA, RCDMC,CDFW, TWI, SVFFC, 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, CDFW, TWI, SVFFC, 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, CDFW, TWI, SVFFC, 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, CDFW, MC, MCWRA, RCDMC, TWI, CT, SVFFC, 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, CDFW, RCDMC, MCWRA,CDFW, MC, SLOC, SVFFC, 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, CDFW, MC, SLOC, SVFFC, TU, CT, TCFT	Urban Development	1, 4	3B	20	0	0	0	0	0	0
SAnt-SCCCS-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization	USFS, USA, USFWS, NMFS, CDFW, RSDSC, MCWRA, MC, SLOC, SVFFC, TU, CT, TCFT	Urban Development	1, 4	3B	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
	structures											
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, CDFW, MC, SVFFC, 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, CDFW, MC, SVFFC, 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-SCCC S-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, USGS, RCDMC SLOC, NMFS, CDFW, CSLRCD, SVFFC, TU, TCFT	Agricultural Development	1, 4	2B	20	47520	0	0	0	0	47520
Nac-SCCC S-1.3	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, USGS, SLOC, NMFS, RCDMC, CDFW, CSLRCD, SVFFC, TU, TCFT	Agricultural Development	1, 4	2B	5	0	0	0	0	0	0
Nac-SCCC S-1.4	Manage agricultural development and restore riparian zones	NRCS, BLM, USGS, RCDMC, SLOC, NMFS, CDFW, CSLRCD, SVFFC, TU, TCFT	Agricultural Development	1, 4	3B	5	0	0	0	0	0	0
Nac-SCCC S-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, USFS, USFWS, CDFW, CCCON, RCDMC, SLOC, FRGP, CDOT, CSLRCD, CT, SVFFC, TU, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1B	5	0	0	0	0	0	0
Nac-SCCC S-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, USFS, USFWS, RCDMC, CDFW, CCCON, RCDMC, SLOC, FRGP, CDOT, CSLRCD, CT, SVFFC, TU, TCFT	Culverts and Road Crossings (Passage Barriers)	1, 4	1B	5	91850	0	0	0	0	91850
Nac-SCCC S-4.1	Develop and implement water management plan for dam operations (or periodically update)	NMFS, USFS, USFWS, CDFW, CCON, MCWRA, SLOC,, FRGP, CT, SVFFC, TU, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Nac-SCCC S-4.2	Develop and implement water management plan for diversion operations (or periodically update)	NMFS, USFS, USFWS, CDFW, CCON, MCWRA, SLOC, FRGP, CT, TU, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	5	0	0	0	0	0	0
Nac-SCCC S-4.3	Provide fish passage around dams and diversions	NMFS, USFS, USFWS, CDFW, CCON, MCWRA, SLOC, FRGP, CT, SVFFC, TU, TCFT	Dams and Surface Water Diversions	1, 3, 4	1A	10	TBD	TBD	TBD	TBD	TBD	TBD

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-SCCC S-5.1	Develop and implement flood control maintenance program (or periodically update)	ACOE, USFS, USFWS, NMFS, CDFW, NRCS, USGS, MC, MCWRA, CSLRCD, CDFW, CT, SVFFC, TU, TCFT	Flood Control Maintenance	1, 4	2B	100	91850	0	0	0	0	91850
Nac-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	USGS, NMFS, CDFW, SLOC, TU, CT, TCFT	Groundwater Extraction	1, 4	1A	5	254350	39775	0	0	0	294125
Nac-SCCC S-6.2	Develop and implement a groundwater monitoring and management program (or review and update)	USGS, NMFS, CDFW, SLOC, SVFFC, TU, CT. TCFT	Groundwater Extraction	1, 4	1A	10	4217625	4217625	4217625	4217625	0	16870500
Nac-SCCC S-7.1	Develop and implement a plan to restore natural channel features	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, SLOC, RSDSC, CSLRCD, CDFW, TWI, CT, SVFFC, TU, TCFT	Levees and Channelization	1, 4	1B	20	0	0	0	0	0	0
Nac-SCCC S-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, CDFW, TWI, CT, SVFFC, TU, TCFT	Levees and Channelization	1, 4	1B	100	10521940	0	0	0	0	10521940
Nac-SCCC S-7.3	Develop and implement stream bank and riparian corridor restoration plan	FEMA, USFS, USFWS, USGS, ACOE, BLM, NRCS, NMFS, MC, RCDMC, SLOC, CSLRCD, CDFW, TWI, CT, SVFFC, TU, TCFT	Levees and Channelization	1, 4	2B	5	0	0	0	0	0	0
Nac-SCCC S-9.1	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control	USFWS, USFS, NMFS, CDFW, MC, SLOC, RSDSC, MCWRA, NRCS, RCDMC, TWI, TU, CT, TCFT	Non-Native Species	1, 3, 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
	measures											
Nac-SCCC S-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFW, MC, SLOC, RCDMC, MCWRA, NRCS, RSDSC, TWI, SVFFC, TU, CT, TCFT	Non-Native Species	1, 3, 5	2B	100	76140	76140	76140	76140	0	304560
Nac-SCCC S-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFW, MC, SLOC, RCDMC, MCWRA, NRCS, RCDMC, TWI, SVFFC, TU, CT, TCFT	Non-Native Species	1, 3, 5	2B	20	62400	0	0	0	0	62400
Nac-SCCC S-10.1	Manage off-road recreational vehicle activity in riparian floodplain corridors	USFWS, USFS, USA, BLM, NMFS, CDFW, MC, MCWRA, WCB.TWI, SVFFC, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	5	0	0	0	0	0	0
Nac-SCCC S-10.2	Review and modify development and management plans for recreational areas and national forests	USFWS, USFS, USA, BLM, NMFS, CDFW, MC, MCWRA, WCB.TWI, SVFFC, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	62400	0	0	0	0	62400
Nac-SCCC S-10.3	Develop, adopt, and implement recreational land-use planning policies	USFWS, USFS, USA, BLM, NMFS, CDFW, MC, MCWRA, WCB, TWI, SVFFC, TU, CT, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	5	0	0	0	0	0	0
Nac-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	DOT, CDOT, USFWS, RWQCB, SWRCB, MC, SLOC, SLOC, MCWRA, CSLRCD, CDFW, TWI, SVFFC, TU, CT, TCFT	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
Nac-SCCC S-11.2	Retrofit storm drains to filter run-off from roadways	DOT, CDOT, USFWS, RWQCB, SWRCB, MC, SLOC, MCWRA, CSLRCD, CDFW, TWI, SVFFC, TU, CT, TCFT	Roads	1, 4	2B	20	0	0	0	0	0	0
Nac-SCCC S-11.3	Develop and implement a plan to remove or reduce approach-fill for	DOT, CDOT, USFWS, RWQCB, SWRCB, MC, SLOC, MCWRA, CSLRCD, CDFW, TWI,	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
	railroad lines and roads	SVFFC, TU, CT, TCFT										
Nac-SCCC S-12.1	Review applicable Integrated Natural Resources Management Plans	USA, USFWS, USFW, NMFS, CDFW, MC, MCWRA, RCDMC, TWI, CT, SVFFC, TU, TCFT	Upslope/Upstream Development	1, 4	2B	20	0	0	0	0	0	0
Nac-SCCC S-13.1	Retrofit storm drains in developed areas	USFS, USA, USFWS, NMFS, CDFW, RCDMC, MCWRA,CDFW, MC, SLOC, SVFFC, TU, CT, TCFT	Urban Development	1, 4	3B	20	62400	0	0	0	0	62400
Nac-SCCC S-13.2	Develop, adopt, and implement urban land-use planning policies and standards	USFS, USA, USFWS, NMFS, CDFW, RCDMC, MCWRA, MC, SLOC, SVFFC, TU, CT, TCFT	Urban Development	1, 4	3B	5	398000	0	0	0	0	398000
Nac-SCCC S-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	USFS, USA, USFWS, NMFS, CDFW, RCDMC, MCWRA,DFG, MC, SLOC, SVFFC, TU, CT, TCFT	Urban Development	1, 4	2B	5	0	0	0	0	0	0
Nac-SCCC S-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, SVFFC, TU, CT, TCFT	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
Nac-SCCC S-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, SVFFC, 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 BPG is one of the smallest of the four BPGs in the SCCCS Recovery Planning Area (Figure 10-1). The main axis of the Carmel River watershed is 28 miles long. In contrast, the main axis of the neighboring Interior Coast Range BPG region is over 180 miles long.

Carmel River – Above Los Padres Dam

The Carmel River Basin BPG 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).

The Carmel River flows into the Pacific Ocean at Carmel Bay, just south of the Monterey Peninsula. This BPG shares some physical characteristics with the Interior Coast Range BPG, 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. However, the Carmel River watershed also exhibits several distinguishing characteristics which sets it apart from the other watersheds and warrants its inclusion as a separate BPG. Beginning in its headwaters in the Santa Lucia Mountains, the Carmel River flows through a several distinctive coastal habitats, starting in a mixed conifer forest, descending into montaine chaparral and oak woodlands, and in the lower elevations to coastal sage scrub and coastal prairie, terminating in coastal dunes at its mouth.

Unlike the other watersheds within the SCCCS Recovery Planning Area which are either dominated by either chaparral/oak woodland (Interior Coast Range BPG) or coniferous vegetative cover (Big Sur Coast), the Carmel contains significant elements of both. Additionally, unlike the other watersheds of the Big Sur BPG to the south, the lower reaches of the Carmel River have an alluvial character similar to the Pajaro and the Salinas watersheds, though it is considerably smaller than the neighboring Salinas River watershed, but larger than any of the systems within the Big Sur BPG.

Carmel River between Los Padres and San Clemente Dams

The mainstem of the Carmel River functions as the conduit connecting the ocean and estuary to extensive steelhead spawning and rearing habitats in the upper watershed.

There are seven major tributaries to the Carmel River (see Figure 10-1). The Carmel River watershed is relatively steep and most of the upper tributaries are naturally perennial (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Carmel River Coalition 2007, Carmel River Conservancy 2004, Smith *et al.* 2004, Philip Williams & Associates 1992).

The Carmel River Estuary is one of the largest estuaries along the South-Central Coast and contains a variety of estuarine habitats, including deep-water, permanently flooded and tidally influenced mudflat habitats that support a wide diversity of aquatic species. The estuary is seasonally closed to the ocean by a sandbar which results in extensive inundation of the surrounding low-lying coastal plain at the mouth of the Carmel River. Upstream base flows of the Carmel River, in combination with periodic tidal inundation of the estuary, create seasonal brackish water conditions. The sandbar is naturally eroded on the seaward side by long-shore currents and winter wave action and over-topped and breached by storm related Carmel River flow.

Carmel River Estuary

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.

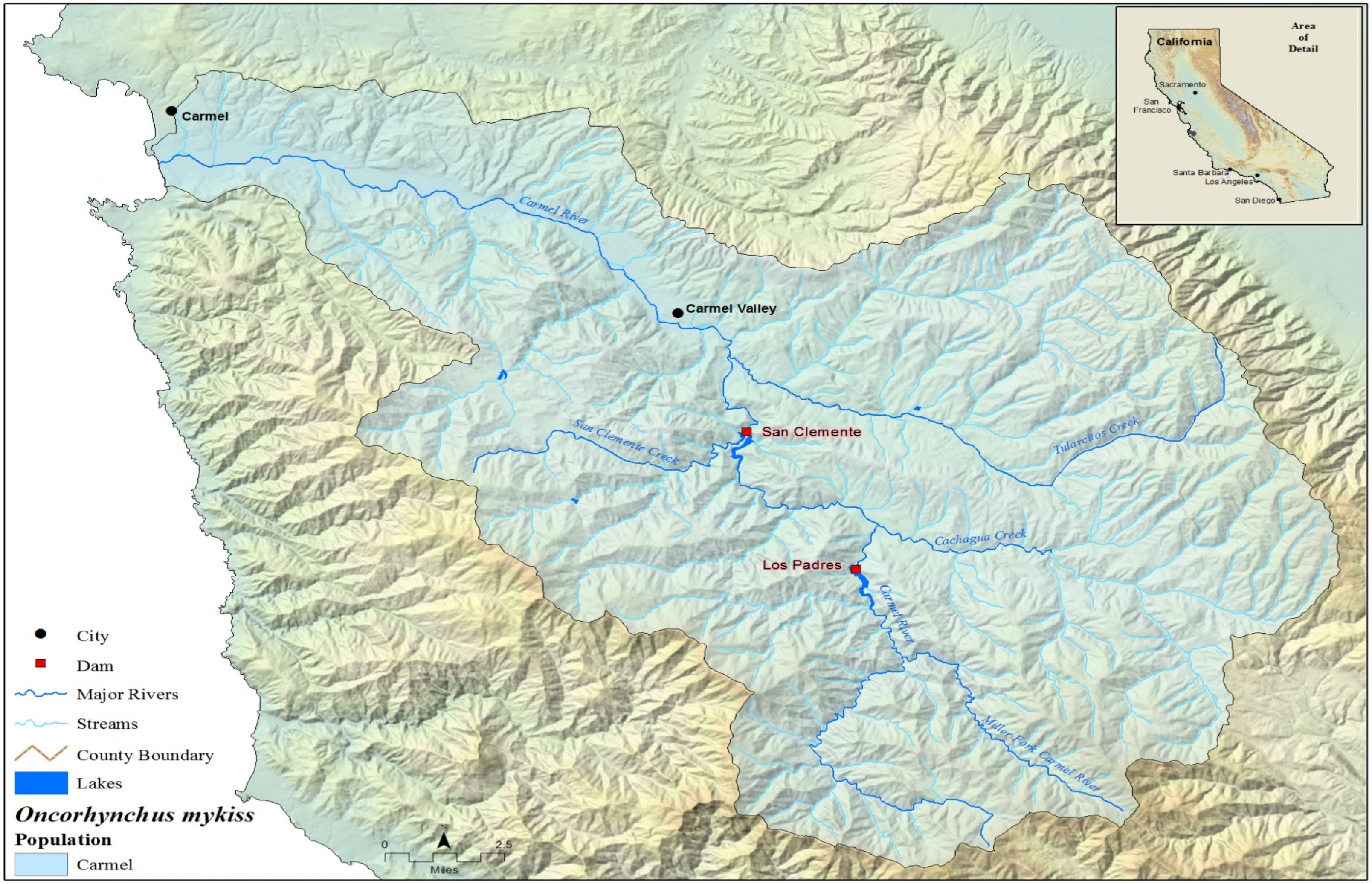

Figure 10-1. The Carmel River Basin BPG. This BPG is comprised of a single watershed (Carmel River).

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, Carmel River Watershed Council 2008, Chiang 2008, Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Carmel River Coalition 2007, Carmel River Watershed Conservancy 2004, Walton 2003, Stephenson and Calcarone 1999, Monterey Peninsula Water Management District 1987, 1983, Kondolf *et al.* 1987, Kondolf 1986, California Department of Water Resources 1978, Greene 1970). See Figure 10-2 for the pattern of federal and non-federal land ownership within the Carmel River watershed.

Carmel River - 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. The Carmel Valley, through which the mainstem of the Carmel River flows, is surrounded by extensive ranches and areas of rural residential land use. Less than one percent of the watershed is under cultivation.

Carmel River - Residential Development

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 Black Rock Creek, 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. Three of these facilities San Clemente, Old Carmel River, and Los Padres Dam have fish passage facilities designed to pass adult steelhead; additionally, smolt emigration facilities are being developed for the Los Padres Dam (California Department of Fish and Wildlife 2012a, California Department of Water Resources 1988, Monterey Peninsula Water Management District 2000, 1987, K. Urquhart personal communication).

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

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/)*

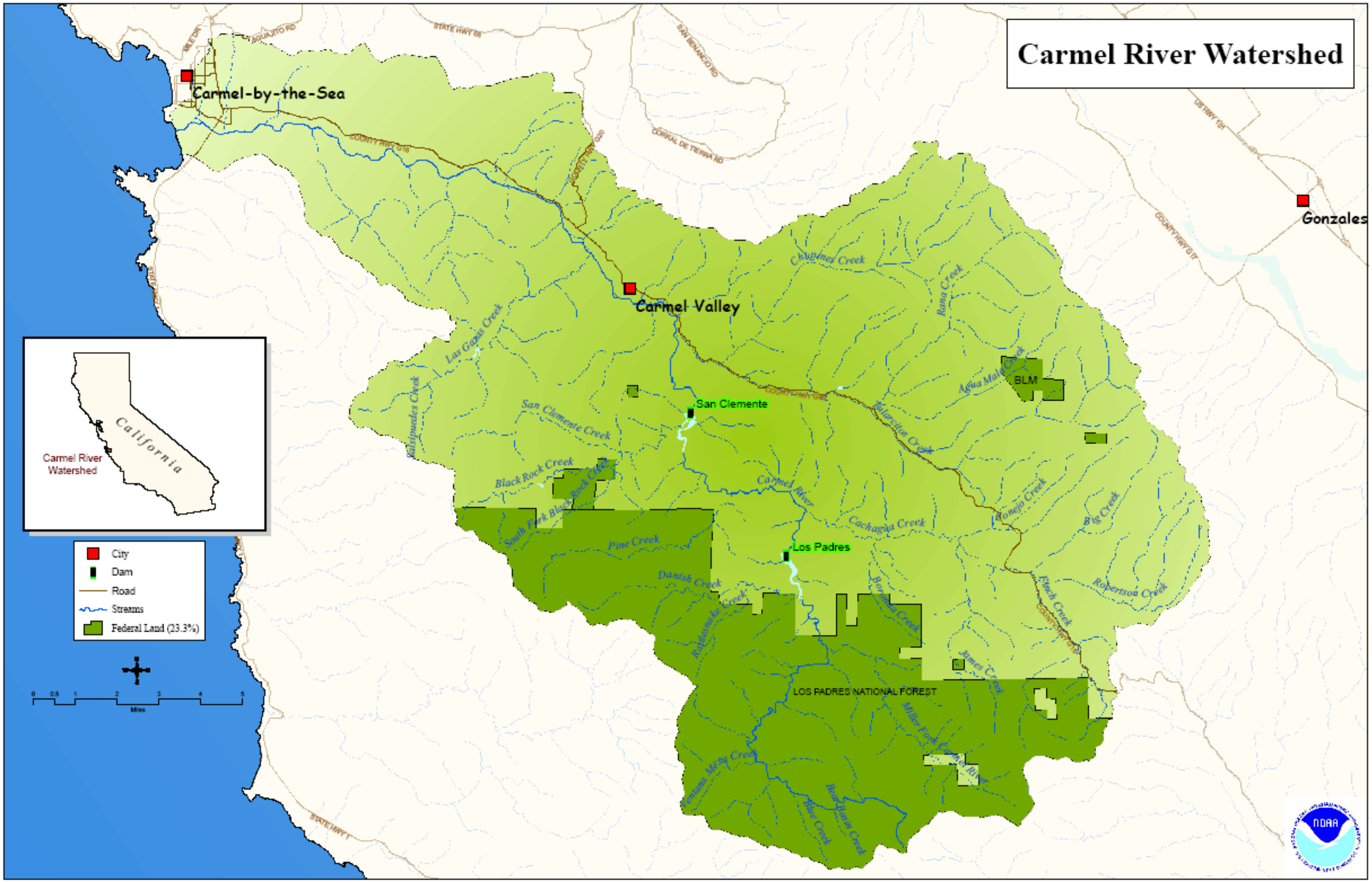

Figure 10-2. Federal and Non-Federal Land Ownership within the Carmel River Watershed.

10.3 CURRENT WATERSHED CONDITIONS

Watershed conditions in this BPG were assessed, with the focus on conditions most directly relevant to steelhead. 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." However, 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). The historic distribution of useable spawning and rearing habitat within the Carmel River watershed has been constrained by the construction and operation of the Los Padres and San Clemente Dams, which have blocked or inhibited the natural pattern of up and downstream migration of adult and juvenile steelhead as well as altered the natural surface flow and reduced the recruitment of essential spawning gravels in the lower river (California Department of Fish and Wildlife 2011b, Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Monterey Peninsula Water Management District 2000-2011, 1987, 1983, Casagrande 2006, Monterey Peninsula Water Management District and Carmel River Watershed Conservancy 2004, Carmel River Conservancy 2004, Stephenson and Calcarone 1999, Dettman and Kelley 1987, 1986, Kondolf 1987, 1986, Snider 1983, California Department of Water Resources 1978; see also, March 2012).

In 1995, in response to groundwater withdrawals drying up portions of the lower river, the California State Water Resources Control Board (CSWRCB) ordered a 70% reduction in Carmel River Diversions. In 1998 the CSWRCB determined that the waters of the Carmel River had been fully appropriated between May 1 and December 31, and all new water right permits issued by the SWRCB must meet instream flow requirements for steelhead. Finally, the SWRCB has issued a Cease and Desist Order in 2009, to reduce diversions (*i.e.*, groundwater pumping) to meet the SWRCB's 1995 and 1998 orders by 2017 (California State Water Resources Control Board 2009, 1998, 1995).

The mainstem contains significant spawning habitat and functions as the conduit connecting the ocean and estuary to extensive spawning and rearing habitats in the upper watershed. The steelhead migration corridor through the lower mainstem of the Carmel River is frequently restricted was a result of excessive groundwater extractions, resulting in low flows and disconnection between the estuary and upstream habitats.

Carmel River – Carmel River Valley

In extreme drought conditions (such as 1987-1991), the failure of the sandbar at the river's mouth to breach, prohibits steelhead from entering the Carmel River as well as escapement of juveniles (Monterey County Peninsula Water Management District 1991-2013). Farther upstream, San Clemente and Los Padres dams (while equipped with fish passage facilities) impede access to the majority of the spawning and rearing habitat of the Carmel River watershed (National Marine Fisheries Service 2002, 2001). Additionally, the two dams impede the downstream transport of sediment necessary to maintain suitable steelhead spawning and rearing habitat in the middle reaches and lower reaches of the Carmel River, and can act as refugia for non-native warm water species (D. W. Alley & Associates 1998, 1997b, 1992b, Dettman 1993, 1989, D. W. Kelley & Associates 1996, 1987, 1984, 1982, Dettman and Kelley 1987, 1986).

A significant portion of the lower Carmel River below San Clemente Dam has been developed for residential and commercial uses. As a result, the mainstem and related floodplain have been altered by bank protection for flood control purposes, thus adversely affecting steelhead habitats, including the related riparian corridor. (Kondolf 1986).

Carmel River Estuary – Residential Encroachment

The Carmel River Estuary also received a low rating. 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). Additionally, reduced flows due to the groundwater extractions and surface diversions and artificial sandbar breaching reduce water levels and encroaching development has reduced estuarine functions, including juvenile steelhead rearing potential. (Anderson *et al*. 2008, California Department of Parks and Recreation 2008, Carmel River Coalition 2007, Perry *et al.* 2007, Casagrande 2006, 2003, Larson *et al.* 2006, Watson and Casagrande 2004, Hagar 2003, D. W. Alley & Associates 1997b, Kitting 1990, Dettman 1984).

Carmel River Estuary – Artificial Breaching

The Carmel River watershed is the only watershed within the SCCCS Recovery Planning Area which has a relatively long-term (20+ years) time-series for adult steelhead runs; this monitoring is conducted principally at the San Clemente and Los Padres Dams. Over the last 20 years (1993-2013) the adults recorded at these two facilities (combined) averaged about 500 adults, though the variation from year to year, can vary by orders of magnitude (see Figures 10-3 and 10-4 below). During the 2011 - 2012 season 470 adults were reported at the San Clemente Dam, and 174 adults at the Los Padres dam. During the most recent 2012-2013 season 249 adults were reported at the San Clemente Dam and 65 adults were reported and the Los Padres Dam. These observed adults, however, do not represent all the steelhead that may have entered the Carmel River system but did not reach the trapping facilities, and were therefore not observed; some un-detected adults may have spawned in the mainstem and tributaries below these dams or emigrated back to the ocean without spawning (Monterey Peninsula Water Management District 1991-2013).

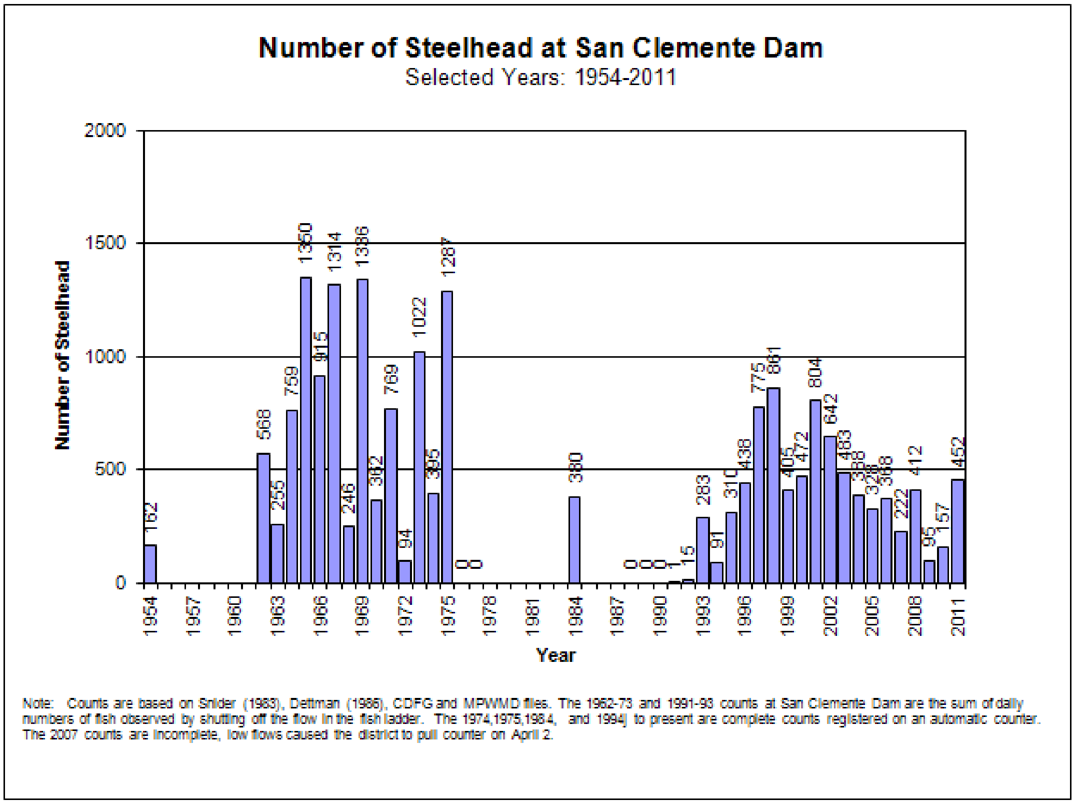

Figure 10-3. Steelhead Counts at San Clemente Dam: 1954 - 2011 (Monterey Peninsula Water Management District).

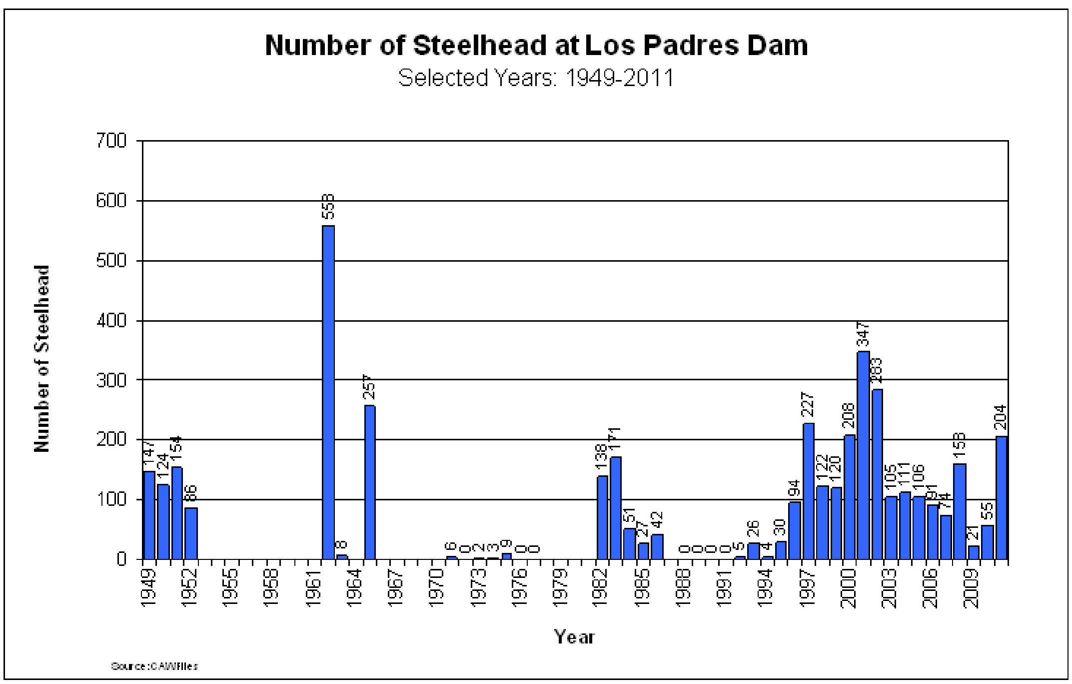

Figure 10-4. Steelhead Counts at Los Padres Dam: 1949 - 2011 (Monterey Peninsula Water Management District).

Native non-anadromous *O. mykiss* populations, while not usually a major proportion of the entire *O. mykiss* population, persist in the mainstem and most of the tributaries above and below these dams. However, during drought conditions such as those that persisted from 1987 through 1991, potentially anadromous juvenile *O. mykiss* could not emigrate out of the watershed and were forced to complete their lifecycle within the river. These fish, as well as others annually rescued from drying reaches of the lower Carmel River are reared in off-channel facilities at the Sleepy Hollow Rearing Facility, operated as part of the Monterey Peninsula Water Management District's Steelhead Rearing Program. These efforts have contributed to the maintenance of the anadromous fraction of the *O. mykiss* population while longer-term recovery and management actions are being developed (Monterey Peninsula Water Management District 2010a, 2010b, 2000-2011, 1988).

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 threats 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 both Los Padres and San Clemente Dams as a result of sediment trapped behind the dams and water management practices, including substantial groundwater use for golf course irrigation; agriculture, urban development. Residential and commercial development and stream bank modifications for flood protection have constricted the lower floodplain of the river. Artificial breaching of the sandbar (both the timing and location) to alleviate flooding of adjacent encroaching residential development has reduced and degraded steelhead rearing habitat within the Carmel River Estuary. Watershed developments have increased erosion and fine sedimentation, particularly in the lower mainstem of the Carmel River, but also within some tributaries, and have contributed to habitat degradation of spawning and rearing habitats (ESA PWA 2012, California Department of Fish and Wildlife 2011b, Monterey Peninsula Water Management District and Carmel River Watershed Conservancy 2004, Monterey Bay National Marine Sanctuary Advisory Council 2003, Dettman 1993, 1989, 1984, Dettman and Kelley 1987, 1986, D. W. Alley & Associates 1998, 1997b, 1992b, D. W. Kelley & Associates 1996, 1987, 1984, Kondolf and Curry 1984, Hecht 1984, Stone 1971, Zinke 1971, U.S. Army Corps of Engineers 1967).

Carmel River - San Clemente Dam

A pervasive threat to anadromous *O. mykiss* throughout the Carmel River Basin BPG 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, primarily due to surface and subsurface water withdrawals. Annual fish rescue and relocation efforts (including relocation to the estuary) are intended to deal with this situation on an interim basis (with rescued fish reared and subsequently released from the Sleepy Hallow Rearing Facility located downstream of the San Clemente Dam). Spawning habitat in the mainstem below the Los Padres and San Clemente Dams has been degraded since 1921 by the retention of spawning gravel and the consequent armoring of the stream bed with large cobbles and boulders downstream of the dams.

As noted above, the Los Padres Dam and San Clemente Dams have also constrained the natural movement of steelhead, both upstream migrating adults and downstream emigrating juveniles, as well as deprived downstream reaches of the Carmel River of significant sediment (and large woody debris) necessary to sustain productive steelhead spawning and rearing habitat. The approved removal of San Clemente Dam will restore volitional access to 25 miles of spawning and rearing habitat, the majority of which is in tributaries between San Clemente Dam and Los Padres Dam (Capelli 2007, Entrix 2006, Raines *et al*. 2002, Monterey Peninsula Water Management District 2000, R2 Resource Consultants 2000, D. W. Alley & Associates 1998, 1992b, D. W. Kelley & Associates 1996, 1987, 1984, 1982, Dettman 1993, 1989, 1984).

See Figure 10-4 for an overview of the dams and other fish passage impediments within the Carmel River Basin BPG, but note the status of fish passage impediments is in flux, with old impediments being removed or modified, while new impediments may be installed, or discovered through updated inventories; a current list of fish passage impediments can be found on the California Department of Fish and Wildlife website:
http://www.cafishpassageforum.org/

Carmel River - 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 and by people recreating on the beach, which causes premature draining of the estuary, and can also affect surrounding groundwater levels which help maintain summer water levels in 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).

The presence of exotic fish species, particularly striped bass (*Marone saxatilis*), has the potential to prey upon and compete with *O. mykiss* and require further monitoring and evaluation of their impacts on steelhead and steelhead habitat. A related potential issue is the expansion of some marine mammal populations (*e.g.*, California sea-lions *Zalophus californianus*) which may prey upon steelhead, particularly when steelhead are temporarily concentrated in enclosed areas, making them more vulnerable to predation. However, this issue has not been the subject of any systematic investigation within the SCCCS DPS and its significance is therefore unknown. Marine mammals are protected under the Marine Mammals Protection Act of 1972 (MMPA), and their management is subject to the provisions of the MMPA (National Marine Fisheries 2011, Steele and Anderson 2006, Middlemas *et al*. 2005, Hinton 2003, Yurk and Trites 2000, Fresh 1997, United State General Accounting Office, 1993, Lowry and Folk 1987, DeMaster *et al.* 1985, Seagers *et al*. 1985).

The spread of other exotic, and invasive species, including plant species, continues to increase with the increasing human population and related changes in land uses within the Carmel River BPG; the early detection, rapid response to, and preferably prevention of, these introductions is an important component in any comprehensive steelhead recovery effort within the Carmel River Basin BPG.

Carmel River Estuary.

Finally, because the lower Carmel River runs through a populated suburban area, with a long angling tradition, taking adult steelhead illegally through poaching is a threat that has been recognized by resource agencies and conservation organizations, particularly during low flow periods when adult fish may be most vulnerable to being trapped in shallow pools with limited opportunities for escape.

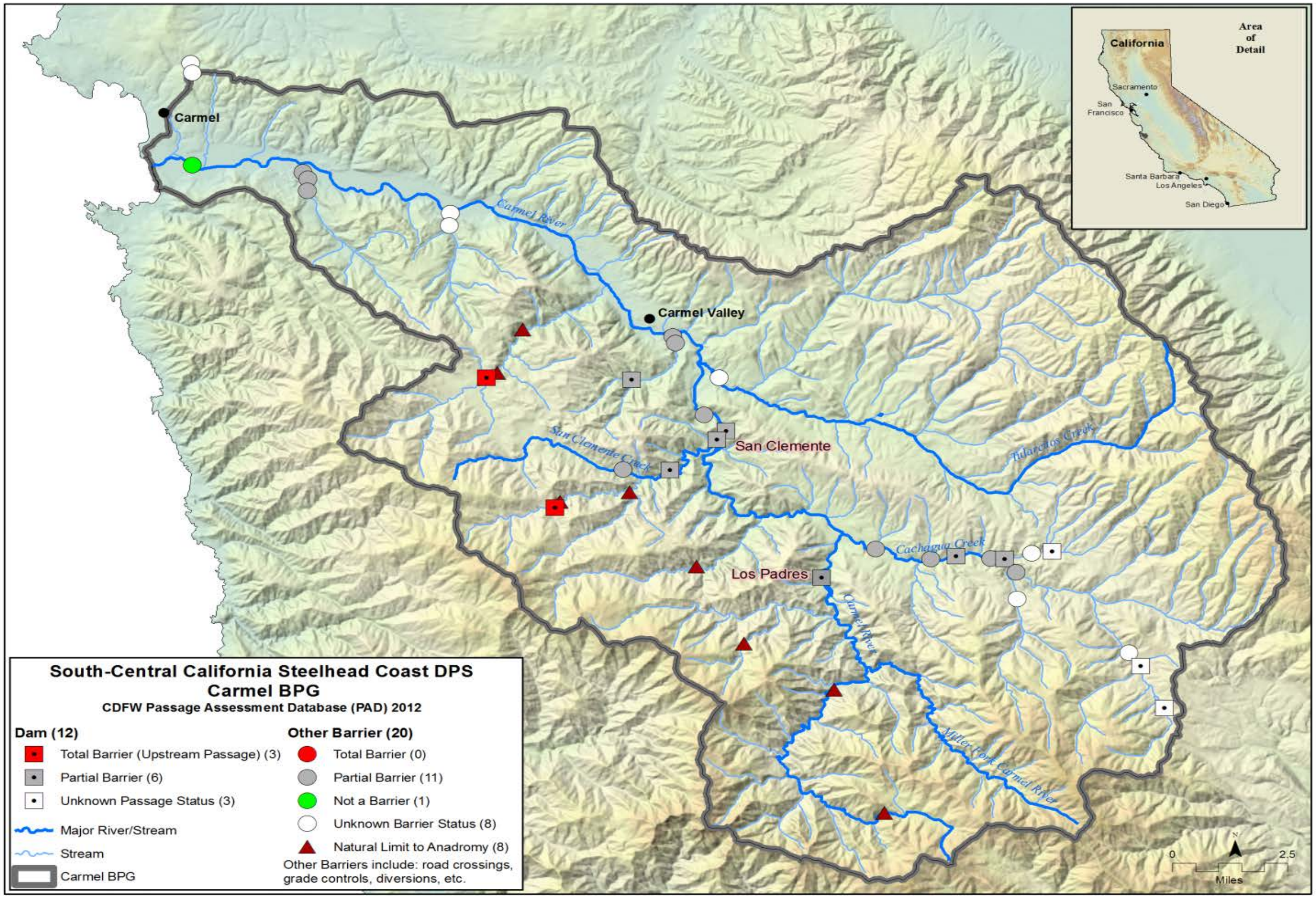

Figure 10-5. Major Fish Passage Impediments, Carmel River Basin BPG. Note: the status of fish passage impediments is in flux, with existing ones being removed or modified, while new ones may be installed, or discovered through updated inventories; a current list of fish passage impediments can be found on the California Department of Fish and Wildlife website: http//www.cafishpassageforum.org/

Table 10-2. Threat source rankings in the Carmel River Basin BPG (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 The ranking for each threat source reflects its significance for the basin as a whole, but does not necessarily indicate it occurs in every part of the watershed (e.g., urban development , levees and channelization, and culverts and crossing are generally restricted to the lower portions of the watershed). Also, 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 within some tributaries could be a significant threat to this 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. While considerable planning has been conducted for the removal of both the Old Carmel River and San Clemente Dams, similar investigations have not yet been initiated for the Los Padres Dam, and are essential for the future removal or modification of this facility. 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, and generated pressure to artificially breach the sandbar to reduce flooding of residential properties. 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 population of the Carmel River Basin 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 guide specific recovery actions. This type of data should be the subject of site-specific investigations in order to refine the recovery actions or to target additional recovery actions as part of any recovery strategy for the Carmel River Basin BPG.

Carmel River Steelhead – c. 1980s (Courtesy Monterey Peninsula Water Management District)

Management of the Carmel River steelhead population will require additional investigations of the population structure and distribution throughout the watershed; these studies should include, but not be limited to, the relative productivity of the various tributaries, how these subpopulations contribute to the diversity of the overall population, and the use of the estuary by steelhead, particularly rearing juveniles. The Los Padres Dam is an important part of a regional water supply system, and its removal or modification will require additional studies, and must take into account its existing and future functions. Additionally, as noted previously, restoring access to habitats above anthropogenic barriers, will, entail controlling or eliminating non-native species that have become established in artificial reservoirs above dams. However, the full removal of dams and associated reservoirs would eliminate refugia habitat favorable to many freshwater non-native species of fishes. In some cases, restoration of habitat conditions (*e.g.*, riparian cover, instream habitat complexity, including adequate spawning substrate) may also be necessary.

Table 10-3 below highlights critical recovery actions for the Carmel River Basin BPG. The following Table 10-4 identifies a full suite of recovery actions necessary to recover this population and prioritizes recovery actions in the Carmel River Basin BPG; this table also provide provisional cost estimates 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	Develop and implement operating criteria to ensure the pattern and magnitude of groundwater extractions and water releases, including releases from San Clemente and Los Padres Dams, provide the essential habitat functions to support the life history and habitat requirements of adult and juvenile steelhead. Remove or physically modify San Clemente, Los Padres, and Old Carmel River Dams* to provide natural rates of steelhead migration to upstream spawning and rearing habitats; passage of smolts and kelts downstream to the estuary and ocean; and restoration of spawning gravel recruitment in the lower mainstem. In the interim ensure provisional fish passage of both adult and juvenile O. *mykiss* around Los Padres, San Clemente and Old Carmel River Dams, seasonal releases from San Clemente and Los Padres Dams, and the provision of spawning gravel and large woody debris within the lower mainstem to support all *O. mykiss* life-history phases, including adult and juvenile migration, spawning, and incubation and rearing habitats. Identify, protect, and where necessary, restore estuarine habitats by providing supplemental water to the estuary and management of artificial breaching of the river's mouth.

* Note: Prior to the removal or modification of these dams appropriate investigations and environmental review should be completed to address regional water supply and environmental issues, including, but not limited to any effects on the existing steelhead resources of the Carmel River watershed.

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 ID Table		Threat Source Legend	
XXXX	Watershed	Car	Carmel River	1	Agricultural Development
SCCCS	Species Identifier – South-Central California Steelhead			2	Agricultural Effluents
1	Threat Source			3	Culverts and Road Crossings (Passage Barriers)
2	Action Identity Number			4	Dams and Surface Water Diversions
Action Rank				5	Flood Control Maintenance
A	Action addresses the first listing factor regarding the destruction or curtailment of the species' habitat			6	Groundwater Extraction
B	Action addresses one of the other four listing factors			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, Chapter 6, Section 6.4, for a discussion of Recovery Action Ranks, and Chapter 3, Section 3.0, for a description of Listing Factors. See Appendix E for a discussion of recovery action cost estimates.

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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-SCCC S-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, MC, MPWMD, CRWC, TU	Agricultural Development	1, 4, 5	2B	20	0	0	0	0	0	0
Car-SCCC S-1.2	Manage agricultural development and restore riparian zone	NRCS, BLM,NMFS, MC, MPWMD, CRWC, CCON, CDFW, CRA, CRSA, CRWC, CVPOA, TU	Agricultural Development	1, 4, 5	2B	5	0	0	0	0	0	0
Car-SCCC S-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM,NMFS, MC, MPWMD, CRWC, CCON, CDFW, CRA, CRSA, CRWC, CVPOA, TU	Agricultural Effluents	1, 4, 5	2B	100	0	0	0	0	0	0
Car-SCCC S-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFW, CCON, MPWMD, CAWC, CRLC, CRSA, CRWC, CRWCO, TU	Culverts and Road Crossings (Passage Barriers)	1, 4, 5	1B	5	96690	0	0	0	0	96690
Car-SCCC S-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, CDFW, CCON, MPWMD, CAWC, CRLC, CRSA, CRWC, CRWCO, TU	Culverts and Road Crossings (Passage Barriers)	1, 4, 5	1B	20	TBD	TBD	TBD	TBD	TBD	TBD
Car-SCCC S-4.1	Develop and implement water management plan for dam operations (or review and modify (*e.g.,* MPWMD Quarterly Water Budget and Low Flow	NMFS, CDFW, MPWMD, CAWC, CRA, CRWC, TU	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
	Memorandum of Agreement)											
Car-SCCC S-4.2	Develop and implement water management plan for diversion operations (or review and modify (*e.g.*, MPWMD Quarterly Water Budget and Low Flow Memorandum of Agreement)	NMFS, CDFW, MPWMD, CAWC, CRA, CRWC, TU	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
Car-SCCC S-4.3	Provide fish passage around dams and diversions	NMFS, CDFW, MPWMD, CAWC, CRA, CRWC, TU	Dams and Surface* Water Diversions *Reflects only the cost and schedule of the removal of San Clemente Dam; the costs and time-frames for 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-SCCC S-5.1	Develop and implement flood control maintenance program	ACOE, FEMA, NMFS, CDFW, MC, COC, MCWRA, MCPW, MPWMD, CRLC, CRSA, CRWC, CRWCO, CVPOA, TU	Flood Control Maintenance	1, 3, 4	2A	100	0	0	0	0	0	0
Car-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	MC, MCWRA, MPWMD, MCPW, NMFS, CDFW, CAWC, CRA, COC, PBCSD, CRLC, CRSA, CRWC, CRWCO, TU	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
Car-SCCC S-6.2	Develop and implement a groundwater	MC, MCWRA, MPWMD, MCPW, NMFS, CDFW,	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
	monitoring and management program (or review and update)	CAWC, CRA, COC, PBCSD, CRLC, CRSA, CRWC, CRWCO, TU										
Car-SCCC S-7.1	Develop and implement a plan to restore natural channel features(or review and update)	NRCS, FEMA, NMFS, CDFW, CRA, COC, CRSA, CRWC, CRWCO, CVPOA, MCPW, MCWRA, MPWMD, MCSA, TU	Levees and Channelization	1, 4	1B	20	4217625	4217625	4217625	4217625	0	16870500
Car-SCCC S-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees(or review and update)	NRSC, FEMA, NMFS, CDFW, CRA, CRSA, CRWC, CRWCO, CVPOA, MCPW, MCWRA,MPWMD, MCSA, TU	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
Car-SCCC S-7.3	Develop and implement stream bank and riparian corridor restoration plan (or review and update)	NRSC, FEMA, NMFS, CDFW, CRA, COC, CRSA, CRWC, CRWCO, CVPOA, MCPW, MCWRA, MPWMD, MCSA, TU	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, CDFW, CDPR, CRA, CRSA, CRWC, CRWCO, TU	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
Car-SCCC S-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CDPR, CRA, CRSA, CRWC, CRWCO, TU	Non-Native Species	1, 3, 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
Car-SCCC S-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CDPR, CRA, CRSA, CRWC, CRWCO, TU	Non-Native Species	1, 3, 5	2B	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 (*e.g.,* the Carmel State Beach Management Plan)	CDPR, CDFW, USFS, NMFS, MC, CRA, COC, CRLC, CRSA, CRWC, CRWCO, MBNMS, MRPD, TU	Recreational Facilities	1, 2, 3, 4, 5	1B	20	0	0	0	0	0	0
Car-SCCC S-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFW, USFS, NMFS, MC, CRA, COC, CRLC, CRSA, CRWC, CRWCO, MBNMS, MRPD, TU	Recreational Facilities	1, 2, 3, 4, 5	1B	20	76140	76140	76140	76140	0	304560
Car-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFW, AMBAG, CRA, COC, CRSA, CRWC, CRWCO, CWPOA, TU	Roads	1, 4	2B	20	0	0	0	0	0	0
Car-SCCC S-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, CDOT, MC,MCPWD, NMFS, CDPR, CDFW, AMBAG, CRA, COC, CRSA, CRWC, CRWCO, CWPOA, TU	Roads	1, 4	2B	20	32260	32260	32260	32260	0	129040
Car-SCCC S-11.3	Develop and implement plan to remove or reduce approach fill f or railroad line and roads	USDOT, CDOT, MC,MCPWD, NMFS, CDPR, CDFW, AMBAG, CRA, COC, CRSA, CRWC, CRWCO, CWPOA, 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
Car-SCCC S-12.1	Develop and implement an estuary restoration and management plan	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFW, AMBAG TWI, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1876000	0	0	0	0	1876000
Car-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, COC, NMFS, CDFW, 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, CDFW, AMBAG, MCPWD, COC, CRA, CRSA, CRWC, CVPOA, TU	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, CDFW, AMBAG, MCPWD, COC, CRA, CRSA, CRWC, CVPOA, TU	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, CDFW, AMBAG, MCPWD, CRA, COC, CRLC, CRSA, CRWCO, CVPOA, PBCSD, MC, MCWRA, MPWMD, TU	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, CDFW, CAWD, CRA, COC,CRLC, CRSA, CRWCO, CVPOA, PBCSD, MC, MCWRA, MPWMD, TU	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
Car-SCCC S-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	USFS, USFWS, CDF&FP, MC, NMFS, CDFW, MPWMD, MRPD, CRA, CRSA, CRWC, CRWCO, TU	Wildfires	1, 4, 5	1B	100	0	0	0	0	0	0

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 includes seven 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 (see Figure 11-1).

The Big Sur Coast BPG topography 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 limited 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 (though some reaches may be intermittent in drought years (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b, Berge *et al.* 2004, Stephenson and Calcarone 1999).

11.2 LAND USE

The Big Sur Coast BPG exhibits the lowest level of development, and the smallest total human population of all the BPGs within the SCCCS Recovery Planning Area. The BPG is also buffered from urban areas by extensive undeveloped open space and rural lands, particularly within the Los Padres National Forest. Human population density averages about 4 persons per square mile. Table 11-1 summarizes land use and population density in the Big Sur Coast BPG.

Several small commercial areas are centered in the unincorporated communities of Carmel Highlands, Big Sur, Gorda, and Ragged Point. The closest resident population centers are the towns of Carmel immediately north of the BPG and San Simeon south of the BPG.

Big Sur River

There are no major cities 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, including Ventana Silver Peak and Santa Lucia Wilderness Areas. Additionally, the Big Sur River, including the North and South Forks, is a federally designated Wild River. There are several State Parks and designated wilderness areas within the Big Sur Coast BPG. Several of the larger State Parks, such as Andrew Molera and Pfeiffer-Big Sur in the Big Sur River watershed, extend inland from the coast.

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 (see Table 11-1). Significantly - and almost uniquely along the coast south of San Francisco – there is relatively little development adjacent to the estuaries associated with the watersheds in the Big Sur Coast BPG, with the notable exception of Highway 1. There are no major dams in this region, though there are seasonal recreational dams and diversions 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, U.S. Forest Service 2004, 2005a, 2005b, Stephenson and Calcarone 1999, California Department of Water Resources 1978). See Figure 11-2 for the pattern of federal and non-federal land ownership within the Big Sur and Little Sur River watersheds.

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

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 Jose Creek	8,826	14	23	20.3	213	0.1%	0.2%	0%	> 99%
Garrapata Creek	6,925	11	16	20.5	63	11%	0.0%	0%	> 99%
Bixby Creek	7,218	11	15	20.8	44	27%	0.0%	0%	> 99%
Little Sur River	26,541	41	64	20.8	70	63%	< 0.3%	0%	> 99%
Big Sur River	37,374	58	92	20.8	142	85%	< 0.7%	0%	> 99%
Willow Creek	10,410	16	26	18.5	35	96%	0.0%	0%	> 99%
Salmon Creek	5,406	8	12	19.5	6	98%	0.0%	0%	> 99%
TOTAL or AVERAGE	**193,561**	**302**	**442**	**20.1**	**2,426**	**60.4%**	**<1%**	**0%**	**>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)
** National Forest Lands only; Military Reservations or State and County Parks not included.*

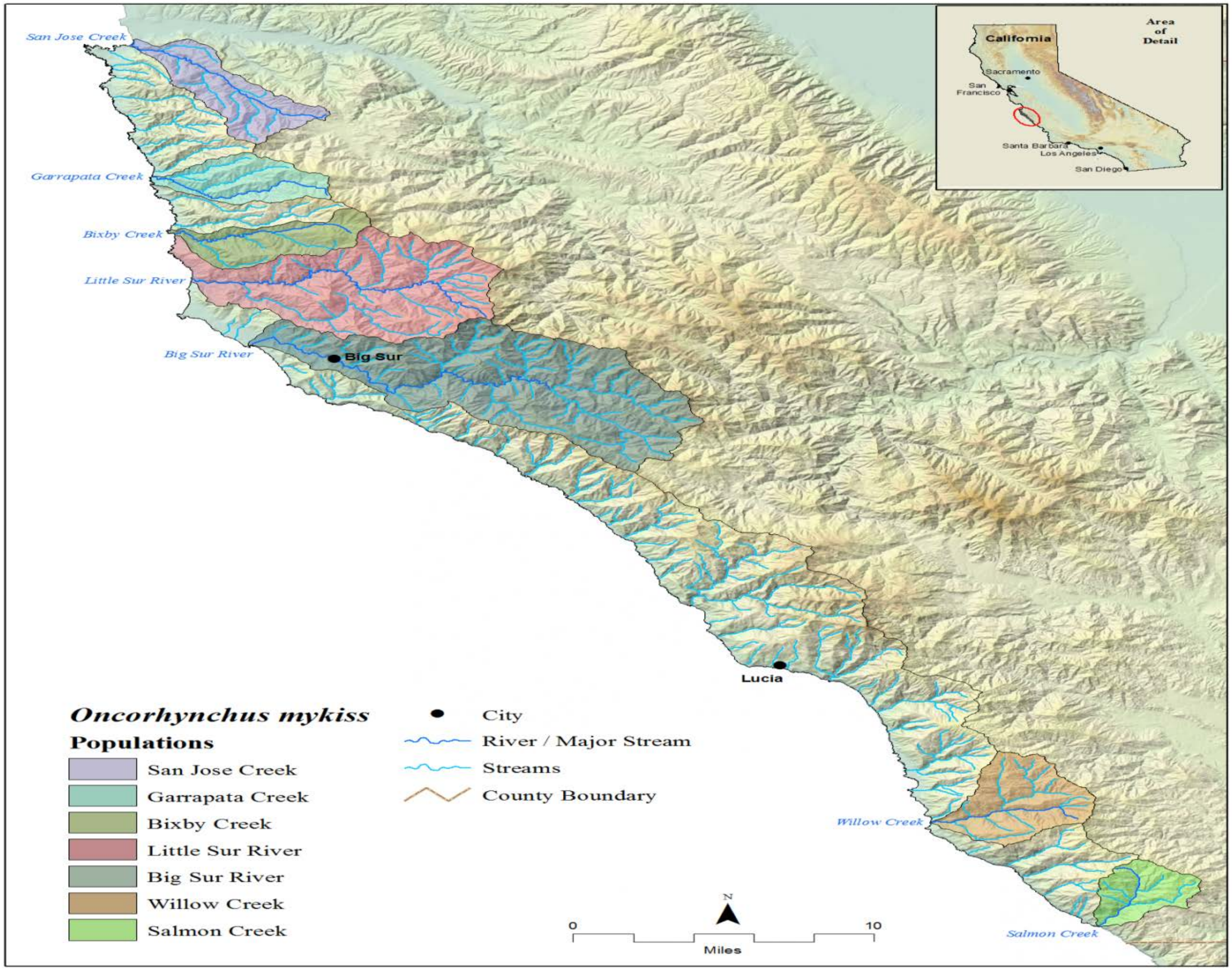

Figure 11-1. The Big Sur Coast BPG. Seven populations/watersheds were analyzed in this region.

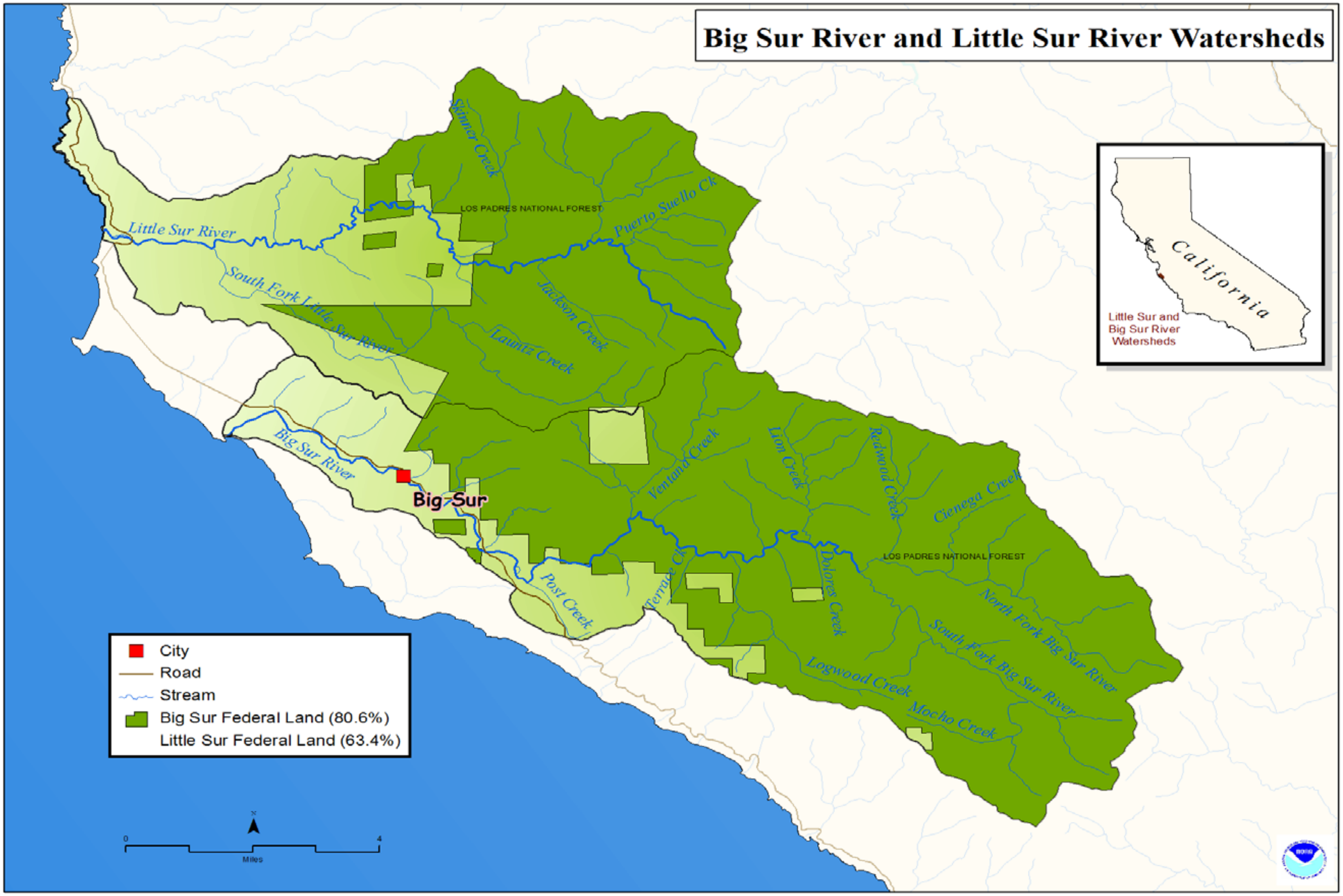

Figure 11-2. Federal and Non-Federal Land Ownership within the Big and Little Sur Watersheds

11.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for seven major drainages in the Big Sur Coast BPG chosen from those identified by the TRT, with the focus on conditions most directly relevant to steelhead. Instream, riparian, and upland habitat conditions in the watersheds in this region are collectively rated the highest of any of the BPGs within the SCCCS Recovery Planning Area 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, though there is a significant development along the middle sections of the Little Sur River, and some livestock grazing in both the Little Sur River and Bixby Creek watersheds. Garrapata Creek 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; however, groundwater extraction operations are common through the Big Coast BPG (Smith *et al.* 2009, 2006, 2005, Garrapata Creek Watershed Community Council 2006, Nelson *et al.* 2006a, 2006b, Casagrande and Smith 2006, 2005, Nedeff 2005, 2004, Nelson 2005, U.S. Forest Service 2004, 2005a, 2005b, Berg *et al.* 2004, Ford 2004, Denise Duffy & Associates 2003, Hagans and Kraemer 2003, Pacific Watershed Associates 2003, Smith *et al*. 2003, Hagar Environmental Science 2002, Kittleson Environmental Consultants 2003, Kittleson Environmental Consultants *et al*. 2002, Stephenson and Calcarone 1999, Collin 1998, 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, San Jose, Garrapata, and Bixby watersheds are characterized by groundwater and surface water diversions, old logging roads (some of which have been decommissioned or weather proofed to reduce erosion), and fish-passage barriers created by log or debris jams associated with past logging activities. The alignment and configuration of the Highway 1 bridge over San Jose Creek has filled in a significant portion of this estuary and constrained the natural migration of the creek channel (Nelson *et al.* 2006a, 2006b, Nedeff 2005, 2004, Nelson 2005, Ford 2004, Entrix Environmental Consultants and Denise Duffy and Associates 2003, Hagan and Kraemer 2003, 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, which constitute the majority of the potential steelhead spawning and rearing habitats in these watersheds. While this limits the amount of accessible spawning and rearing habitat, particularly in Salmon Creek, the most significant developments within the Big Sur River are water supply development (including groundwater and surface water diversions) in the lower reaches and barriers created by culverts, fords, and seasonal rock dams built for recreational purposes. Additionally, both public and private recreational development within the vicinity of U.S. Highway 1 have encroached on riparian habitat and resulted in a variety of associated recreational activities (*e.g.*, collection of natural woody debris for campfires, construction of seasonal rock dams) which impacts steelhead habitats, particularly summer rearing habitat (Allen and Riley 2012, California Department of Fish and Wildlife 2012a, 2011a, 2011a Kittleson Environmental Associates 2002, Denis Huffy & Associates 1998, Titus 1994, Rischbieter 1990a, 19990b, .

Salmon Creek (above Highway 1)

Salmon Creek (below Highway 1)

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 (above Highway 1)

11.4 THREATS AND THREAT SOURCES

The number of threats identified in the CAP Workbook analysis in the Big Sur Coast BPG region is very low compared to other BPGs, 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 threats 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. The most pervasive threats stem from roads (as a source of sedimentation), wildfires, fish passage barriers, and groundwater extractions which pose significant threats to rearing juvenile steelhead, particularly in dry years (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b; see also references cited above).

Big Sur Coast – Post-Fire Debris Control Structure

See Figure 11-3 for the location of major fish passage impediments within the Big Sur Coast; but note that the status of fish passage impediments is in constant flux, with old structures being removed or modified, while new impediments may be installed, or discovered through updated inventories; a current inventory of fish passage impediments can be found on the California Department of Fish and Wildlife website:
http://www.cafishpassageforum.org/

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. Groundwater extractions 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, Hagans and Kraemer 2003, Hagar Environmental Science 2002, McNight 2002).

The lower mainstem of Salmon Creek between the ocean and the Highway 1 culvert provides spawning and rearing habitat for anadromous *O. mykiss* (the culvert is impediment to upstream fish passage under low-flow conditions). 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 less than two miles above the mouth of the creek, though recolonization, both from the upstream resident *O. mykiss* and steelhead dispersal from nearby watersheds, is a possibility.

The 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 (particularly in San Jose Creek and the Big Sur River), and surface water diversions; and non-point pollution, including sedimentation resulting road cuts, including abandoned logging roads.

Water extractions along the lower reaches of the Big Sur River have affected flow conditions in the lower river and lagoon, and small seasonal rock dams constructed for recreational purposes, as well as at-grade road crossings have degraded habitat in this reach of the Big Sur River. (Allen and Riley 2012, California Department of Fish and Wildlife 2011a, 2011b, Hanson 2011, Titus 1994, Monterey County 1986). The natural rock barrier in the lower portion of the Big Sur River gorge upstream of the Pfeiffer Big Sur State Park restricts access to the majority of the potential steelhead spawning and rearing habitat within the Big Sur River watershed. As a result the 92 miles of stream length for the Big Sur River in Table 11-1 is largely inaccessible to anadromous *O. mykiss*.

Wildfires within are a continuing pervasive threat 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).

Finally, the spread of exotic and invasive species, including plant species, continues to increase with the increasing human population and related changes in land uses within the Big Sur Coast BPG; for example, Cape Ivy (*Delairea odorata*) in watersheds such as Garrapata Creek has become more extensive and potentially invasive in other watersheds within the Big Sur Coast BPG. The early detection, rapid response to, and preferably prevention of, these introductions is an important component in any comprehensive steelhead recovery effort within the Big Sur Coast BPG.

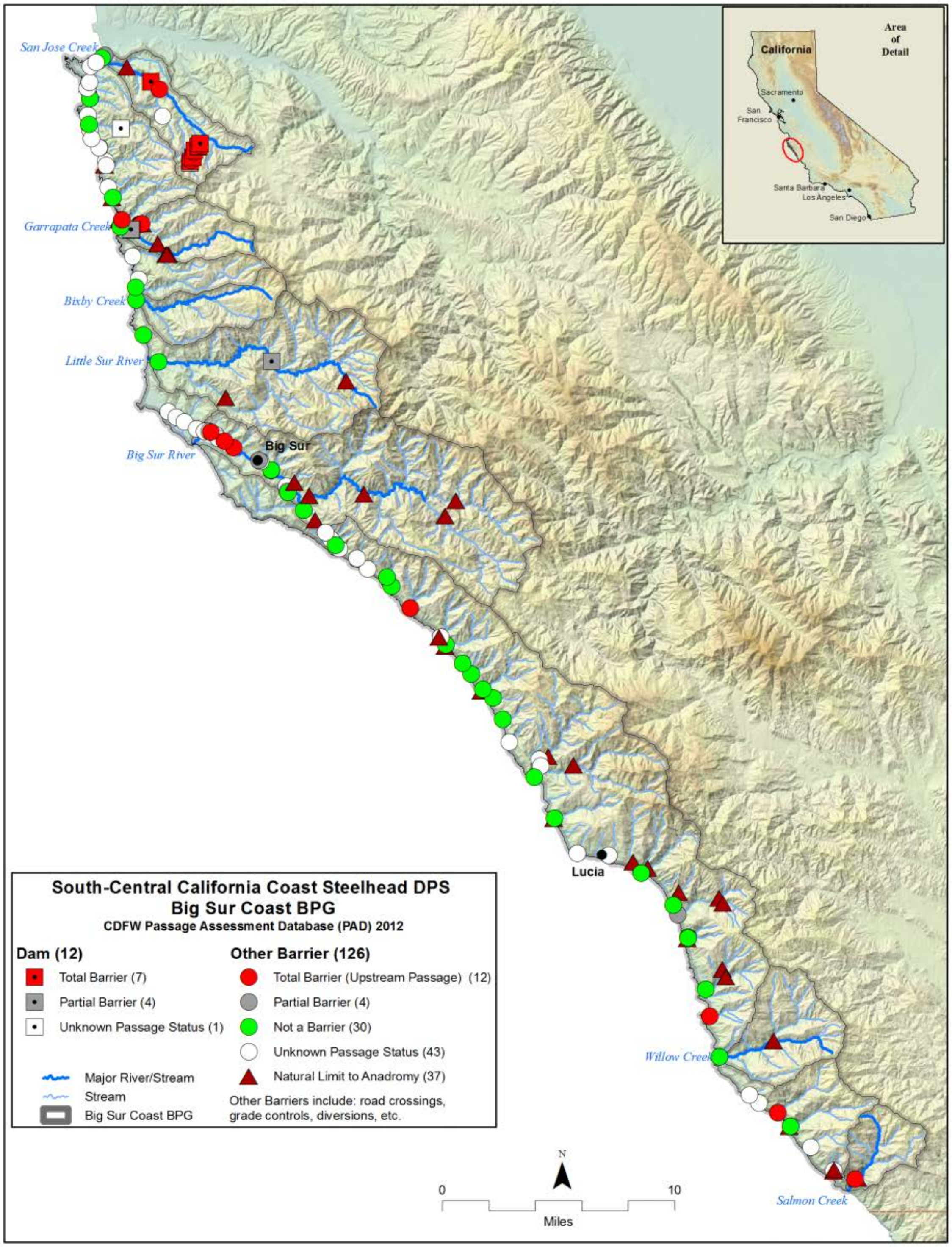

Figure 11-3. Major Fish Passage Impediments, Big Sur Coast BPG. Note: the status of fish passage impediments is in flux, with existing ones being removed or modified, while new ones may be installed, or discovered through updated inventories; a current inventory of fish passage impediments can be found on the California Department of Fish and Wildlife website: http://www.cafishpassageforum.org/

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	Yellow	Red	Light green	Light green	Red	Light green	Light green
Roads	Yellow	Red	Light green	Dark green	Dark green	Light green	Light green
Non-Point Pollution	Red	Red	Light green	Dark green	Light green	Dark green	Dark green
Groundwater Extraction	Red	Light green	Dark green	Yellow	Red	Dark green	Dark green
Recreational Facilities	Dark green	Dark green	Dark green	Light green	Yellow	Light green	Dark green
Wildfires	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Dams and Surface Water Diversions	Dark green	Light green	Dark green	Light green	Red	Dark green	Dark green
Non-Native Species	Dark green	Yellow	Dark green	Dark green	Light green	Dark green	Dark green

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 best preserved watersheds within any of the four BPGs 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 least altered, though there are significant developments along the middle portions of the Little Sur (including livestock grazing) 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 persistent threat throughout the Big Sur Coast BPG.

Increased development within several of these watersheds (*e.g.*, San Jose Creek and Little Sur River), including higher road densities, (and altered natural fire regimes), could significantly increase fine sediment loads 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 (through loss of riparian canopy cover).

Reducing 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 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.

The threat sources discussed in this chapter should be the focus of a variety of recovery actions to address 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 guide specific recovery actions. This type of data should be the subject of site-specific investigations in order to refine the recovery actions or to target additional recovery actions as part of any recovery strategy for the Big Sur Coast BPG.

Big Creek Steelhead – 2013 (Courtesy Mark D. Readdie)

Management of the steelhead populations of the Big Sur Coast BPG will require additional investigations of the population structure of the BPG; these studies should include, but not be limited to, the role of the various individual watersheds in the maintenance of the BPG as a whole (including dispersal rates between watersheds), how these individual populations contribute to the diversity of the BPG, and the role and use of the estuaries by steelhead, particularly rearing juveniles.

Table 11-3 below highlights critical Recovery Actions recovery actions for the Big Sur Coast BPG. The following Tables 11-4 through 11-10 identify a full suite of recovery actions necessary to recover these populations and describe and prioritize recovery actions for each watershed in the Big Sur Coast BPG. These tables also provide provisional cost estimates 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	Develop and 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, including management of the artificial breaching of the creek's mouth.
Little Sur River	Develop and 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	Develop and implement operating criteria to ensure the pattern and magnitude of groundwater extractions and surface diversions, 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 ID Table		Threat Source Legend	
XXXX	Watershed	SJC	San Jose Creek	1	Agricultural Development
SCCCS	Species Identifier – South Central California Steelhead	Gar	Garrapata Creek	2	Agricultural Effluents
1	Threat Source	Bix	Bixby Creek	3	Culverts and Road Crossings (Passage Barriers)
2	Action Identity Number	LS	Little Sur River	4	Dams and Surface Water Diversions
Action Rank		BS	Big Sur River	5	Flood Control Maintenance
A	Action addresses the first listing factor regarding the destruction or curtailment of the species' habitat	WC	Willow Creek	6	Groundwater Extraction
B	Action addresses one of the other four listing factors	SC	Salmon Creek	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, Chapter 6, Section 6.4, for a discussion of Recovery Action Ranks, and Chapter 3, Section 3.0, for a description of Listing Factors. See Appendix E for a discussion of recovery action cost estimates.

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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-SCCC S-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, CCON, MC, RCDMC, MPWMD, TWI, TBSLT, VWA, TU	Agricultural Development	1, 3, 4	2B	20	0	0	0	0	0	0
SJC-SCCC S-1.2	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, MC, RCDMC, MPWMD, CCCON, CDFW, TWI, TBSLT, VWA, TU	Agricultural Effluents	1, 3, 4	2B	100	0	0	0	0	0	0
SJC-SCCC S-3.1	Conduct watershed-wide fish passage barrier assessment (or review and update)	NMFS, CDFW, CCCON, MPWMD, TWI, TBSLT, VWA, TU	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2B	5	96690	0	0	0	0	96690
SJC-SCCC S-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	NMFS, CDFW, CCCON, MPWMD, TWI, TBSLT, VWA, TU	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	1A	5	0	0	0	0	0	0
SJC-SCCC S-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFW, CCCON, MPWMD, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
SJC-SCCC S-4.2	Provide fish passage around dams and diversions	NMFS, CDFW, CCCON, MPWMD, TWI, TBSLT, VWA, TU	Dams and Surface Water Diversions	1, 3, 4	2A	5	0	0	0	0	0	0
SJC-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	MC, MCWRA, MPWMD, NMFS, USGS, CDFW, TWI, TBSLT, VWA, TU	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
SJC-SCCC S-6.2	Develop and implement a groundwater monitoring and management program (or review and update)	MC, MCWRA, MPWMD, NMFS, USGS, CDFW, TWI, TBSLT, VWA, TU	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
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, CDFW, 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, CDFW, CDPR, CNPS, TWI, TBSLT, VWA, TU	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, CDFW, CDPR, CNPS, TWI, TBSLT, VWA, TU	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, CDFW, 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, CDFW, NMFS, MC, CRA, MBNMS, MRPD, TWI, TU	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, CDFW, AMBAG TWI, TBSLT, VWA, TU	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, CDFW, AMBAG TWI, TBSLT, VWA, TU	Roads	1, 4	1A	20	32260	32260	32260	32260	0	129040
SJC-SCCC S-11.3	Develop and implement a plan to remove or reduce approach-fill for railroad lines and	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFW, AMBAG TWI, TBSLT, VWA, TU	Roads	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
	roads											
SJC-SCCC S-12.1	Develop and implement an estuary restoration and management plan	USDOT, CDOT, MC, MCPWD, NMFS, CDPR, CDFW, AMBAG TW, TBSLT, VWA I, TU	Upslope/Upstream Activities	1, 4, 5	1A	5	670000	0	0	0	0	670000
SJC-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, COC, NMFS, CDFW, MCPWD,TWI, TBSLT, VWA	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
SJC-SCCC S-13.1	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	CCCOM, MC, NMFS, CDFW, AMBAG, MCPWD, TWI, TBSLT, VWA, TU	Urban Development	1, 4, 5	2B	5	398000	0	0	0	0	398000
SJC-SCCC S-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFW, AMBAG, MCPWD, TWI, TBSLT, VWA, TU	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
SJC-SCCC S-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCD, SWRCB, MC, NMFS, CDFW, AMBAG, MCPWD, TWI, TBSLT, VWA, TU	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
SJC-SCCC S-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP, USFS, USFWS, MC, NMFS, CDFW, MPWMD, MRPD, TBSLT, VWA, TU	Wildfires	1, 4, 5	2B	100	0	0	0	0	0	0

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 Garrapata Creek Watershed Assessment and Restoration Plan, 2006)	NMFS, CDFW, CCCON, MC, TWI, GCWC, TBSLT, VWA, TU	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, CDFW, CCCON, MC, TWI, GCWC, TBSLT, VWA, TU	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, CDFW, CCON. MC, GCWC, TBSLT, VWA, TU	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, CDFW, CCON. MC, GCWC, TBSLT, VWA, TU	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 (or review and update)	NMFS, USGS, CDFW, CCON, MC, GCWC, TBSLT, VWA	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
Gar-SCCC S-6.2	Develop and implement a groundwater monitoring and management program (or review and update)	NMFS, USGS, CDFW, CCON. MC, GCWC, TU	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
Gar-SCCC S-9.1	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CNPS, CDPR, MC, GCWC, TBSLT, VWA, TU	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, CDFW, CNPS, CDPR, MC, GCWC, TBSLT, VWA, TU	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
	(or periodically review and update Garrapata Creek Watershed Assessment and Restoration Plan, 2006)											
Gar-SCCC S-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CNPS, CDPR, MC, GCWC, TBSLT, VWA, TU	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, CDFW, WCB, NMFS, USFS,USFWS, MC, GCWC, TBSLT, VWA, TU	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, CDFW, WCB, NMFS, USFS, USFWS, MC, GCWC, TBSLT, VWA, TU	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 (or periodically review and update Garrapata Creek Watershed Assessment and Restoration Plan, 2006)	USDOT, NMFS, CDOT, MC, CDPR, CDFW, AMBAG TWI, GCWC, TBSLT, VWA, TU	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, CDFW, AMBAG TWI, GCWC, TU	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, CDFW,TWI, GCWC, TBSLT, VWA, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	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
Gar-SCCC S-14.1	Review California Regional Water Quality Control Boards Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFW, AMBAG, TWI, GCWC, TBSLT, VWA, TU	Urban Effluents	1, 4, 5	2B	20	0	0	0	0	0	0
Gar-SCCC S-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, MC, NMFS, CDFW, GCWC, TBSLT, VWA, TU	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, CDFW, CCCON , MC, TWI, CCORP, TBSLT, VWA, TU	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, CDFW, CCCON, MC,TWI, CCORP, TBSLT, VWA ,TU	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, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	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 (or review and update)	NMFS, USGS, CDFW, CCON, MC, TWI, TU	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 (or review and update)	NMFS, USGS, CDFW, CCON CCORP, MC, TWI, TBSLT, VWA, TU	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, CDFW, CNPS, CDPR, MC, TWI, TBSLT, VWA, TU	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, CDFW, CNPS, CDPR, MC, TWI, CCORP, TBSLT, VWA, TU	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, CDFW, CNPS, CDPR, MC, TWI, TU	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
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 Management Plan)	CDPR, CDFW, WCB, NMFS, USFS, USFWS, MC, TWI, CCORP, TBSLT, VWA, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
Bix-SCCCS-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFW, WCB, NMFS, USFS, USFWS, MC, TWI, CCORP, TU	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, CDFW, AMBAG TWI, CCORP, TBSLT, VWA, TU	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, CDFW, 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, CDFW, AMBAG, TWI, TBSLT, VWA, TU	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, CDFW, 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, TU	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, CDFW, 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, CDFW, CCCON, MC, TWI, CCCORP,, TBSLT, VWA, TU	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, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	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, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	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, CDFW, CCCORP, TBSLT, VWA CCCON, MC, TWI, TU	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 (or review and update)	NMFS, USGS, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
LS-SCCCS-6.2	Develop and implement a groundwater monitoring and management program (or review and update)	NMFS, USGS, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	Groundwater Extraction	1, 4	3B	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 21-26	FY 1-100
LS-SCCCS-9.1	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, WCB, NMFS, USFW, MC, TW CCCORP, TWI, TBSLT, VWA, TU	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, CDFW, WCB, NMFS, USFS, USFWS, USFWS, MC, TWI, CCCORP, TBSLT, VWA, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
LS-SCCCS-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	CDOT, MC, CDPR, CDFW, AMBAG TWI, TBSLT, VWA, TU	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, CDFW, AMBAG TWI, TBSLT, VWA	Roads	1, 4	1B	20	0	00	0	0	0	0
LS-SCCCS-12.1	Develop and implement an estuary management plan (or periodically update)	USDOT, CDOT, MC, NMFS, USFS, CDFW, AMBAG TWI, CCCORP,	Upslope/Upstream Activities	1, 2, 3, 4, 5	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 21-26	FY 1-100
		TBSLT, VWA, TU										
LS-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, NMFS, CDFW, CCCORP, TWI, TBSLT, VWA, TU	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, CDFW, AMBAG, TWI. CCCORP, TU	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, CDFW, AMBAG, TWI, TBSLT, VWA, TU	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, CDFW, AMBAG, TWI, TBSLT, VWA, TU	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, CDFW, TBSLT, VWA, TU	Wildfires	1, 4, 5	1B	100	0	0	0	0	0	0

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-SCCC S-1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, CCON, MC, RCDMC, TWI, TBSLT, VWA, TU	Agricultural Development	1, 3, 4	3B	5	47520	0	0	0	0	47520
BS-SCCC S-3.1	Conduct a watershed-wide fish passage barrier assessment	CDOT, NMFS, CDFW, CCCON, MC, TWI, CCCORP, TBSLT, VWA, TU	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2A	5	96690	0	0	0	0	96690
BS-SCCC S-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed	CDOT, NMFS, CDFW, CCCON, MC, TWI, CCCORP, TBSLT, VWA, TU	Culverts and Road Crossings (Passage Barriers)	1, 3, 4	2A	5	0	0	0	0	0	0
BS-SCCC S-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFW, CCCON, MC, TWI, TBSLT, VWA	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
BS-SCCC S-4.2	Provide fish passage around dams and diversions	NMFS, USFS, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	Dams and Surface Water Diversions	1, 3, 4	2A	5	0	0	0	0	0	0
BS-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USGS, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
BS-SCCC S-6.2	Develop and implement a groundwater monitoring and management program (or review and update)	NMFS, USGS, CDFW, CCCON, MC, TWI, TBSLT, VW, TUA	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
BS-SCCC S-9.1	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA, TU	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
BS-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, CDFW, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA, TU	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
BS-SCCC S-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CNPS, CDPR, MC, TWI, CCCORP,	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
		TBSLT, VWA, TU										
BS-SCCC S-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, CDFW, CCCON, WCB, NMFS, USFS, USFWS, MC, TWI, CCCORP, TBSLT, VWA, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
BS-SCCC S-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFW, CCCON, WCB, NMFS, USFS, USFWS, MC, TWI, CCCORP, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
BS-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	CDOT, MC, CDPR, CDFW, AMBAG TWI, TBSLT, VWA, TU	Roads	1,4	2B	20	0	0	0	0	0	0
BS-SCCC S-11.2	Develop and implement plan to remove or reduce approach-fill road and roads	CDOT, MC, CDPR, CDFW, AMBAG, TWI, TBSLT, VWA, TU	Roads	1,4	3B	20	0	0	0	0	0	0
BS-SCCC S-12.1	Develop and implement an estuary restoration and management plan	CDOT, MC, NMFS, USFS, CDFW, AMBAG, TWI, CCCORP, TBSLT, VWA, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1340000	0	0	0	0	1340000
BS-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, MC, NMFS, USFS, CDFW, CCCORP, TWI, TBSLT, VWA, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
BS-SCCC S-14.1	Review, assess and modify residential and commercial wastewater septic treatment facilities	RWQCD, SWRCB, MC, NMFS, CDFW, AMBAG, TW, TBSLT, VWA, TUI	Urban Effluents	1, 4, 5	2B	100	0	0	0	0	0	0
BS-SCCC S-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCD, SWRCB, MC, NMFS, CDFW, AMBAG, TWI, TBSLT, VWA, TU	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-SCCC S-14.3	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCD, SWRCB, MC, NMFS, CDFW, AMBAG, TWI, TBSLT, VWA, TU	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
BS-SCCC S-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, MC, NMFS, CDFW, TBSLT, VWA, TU	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, CDFW, CCCON, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, CCCON, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	Dams and Surface Water Diversions			5	91850	0	0	0	0	91850
WC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USGS, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	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 (or review and update)	NMFS, USGS, CDFW, CCCON, MC, TWI, TBSLT, VWA, TU	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, CDFW, CNPS, CDPR, MC, TBSLT, VWA C, TWI, CCCORP, TU	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, CDFW, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, CNPS, CDPR, MC, TWI, CCCORP, TBSLT, VWA, TU	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
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, CDFW, CCCON, WCB, NMFS, USFS, USFWS, MC, TWI, CCCORP, TBSLT, VWA, TU	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
WC-SCCCS-10.2	Develop and implement a public educational program on watershed processes	CDPR, CDFW, CCCON, WCB, NMFS, USFW, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, AMBAG, TWI, TBSLT, VWA, TU	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, CDFW, 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, CDFW, AMBAG, TWI, TU	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, CDFW, CCCORP, TWI, TBSLT, VWA, TU	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, CDFW, AMBAG, TWI, TU	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, CDFW, TBSLT, VWA, TU	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, CDFW, CCCON, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, CCCON, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, CCCON, WCB, NMFS, USFS,USFWS, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, CCCON, WCB, NMFS, UFS, USFWS, MC, TWI, CCCORP, TBSLT, VWA, TU	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, CDFW, 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, CDFW, AMBAG, TWI, TBSLT, VWA, TU	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, CDFW, CCCORP, TWI, TBSLT, VWA, TU	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, CDFW, AMBAG, TWI, TBSLT, VWA, TU	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, CDFW, TBSLT, VWA, TU	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 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. The upper watersheds in the San Luis Obispo Terrace BPG are similar to the Big Sur Coast BPG, but because the spine of the Santa Lucia Range veers inland to the south, the lower portions of the watersheds are relatively flat and cut across raised marine coastal terraces before entering the Pacific Ocean.

The 12 watersheds (north to south) analyzed in this BPG were: San Carpoforo Creek, Arroyo de la Cruz, Little Pico Creek, 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 (see Figure 12-1).

The Morro Bay region al includes the separate watersheds of Morro Creek, which now empties directly 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 complex. 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.

Arroyo de la Cruz Estuary

San Simeon Creek Estuary

In general, the higher elevations receive greater amounts of precipitation as a result of the orographic effect of winter storms passing over the coastal ranges, 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).

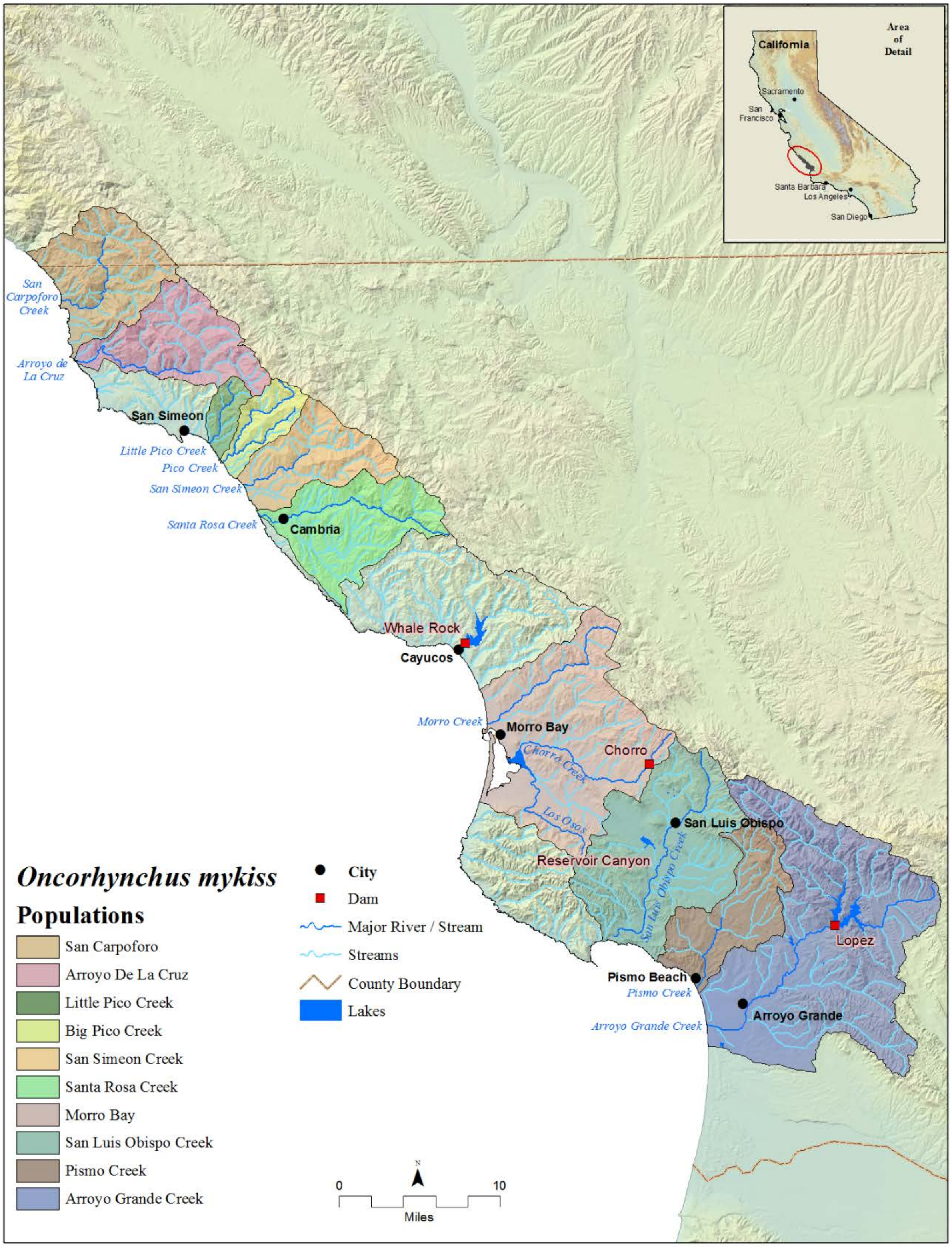

Figure 12-1. The San Luis Obispo Terrace BPG. Twelve steelhead populations/watersheds were analyzed in this region, including three in the Morro Bay region.

12.2 LAND USE

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.

Pico 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, 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. Table 12-1 summarizes land use and population density in this BPG region (Hunt & Associates 2008b, Kier Associates and National Marine Fisheries Service 2008b, Callenberger *et al.* 2002, Stephenson and Calcarone 1999, California Department of Water Resources 1978).

The increasing population density towards the southern portions of this BPG region is reflected in land-use changes, such as 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), private ownership of land, and correspondingly lower amounts of open space. The coastal terraces of the southern watersheds receive high recreational and urban use. The estuaries associated with the watersheds of the southern portion of the San Luis Obispo Terrace BPG have been subjected to extensive development (with the notable exceptions of Little Pico and Pico Creeks). 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 (Hunt & Associates 2008b, Biotic Resources Group 2006, California Department of Water Resources 1988). See Figures 12-2 through 12-5 for the pattern of federal and non-federal land ownership within the San Luis Obispo Terrace BPG.

San Luis Obispo Creek Estuary

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

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%
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.*

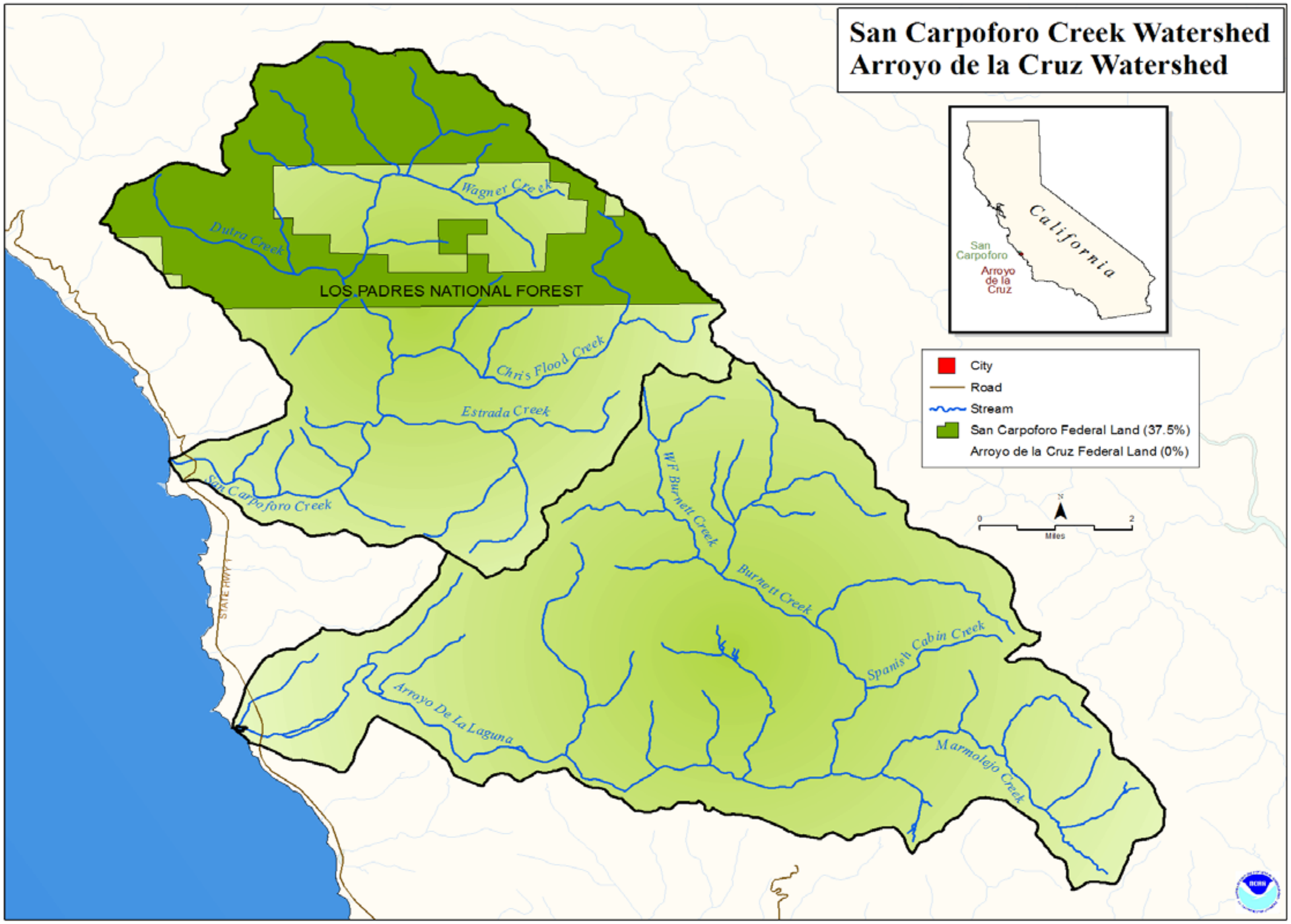

Figure 12-2. Federal and Non-Federal Land Ownership within the San Carpoforo Creek and Arroyo de la Cruz Watersheds.

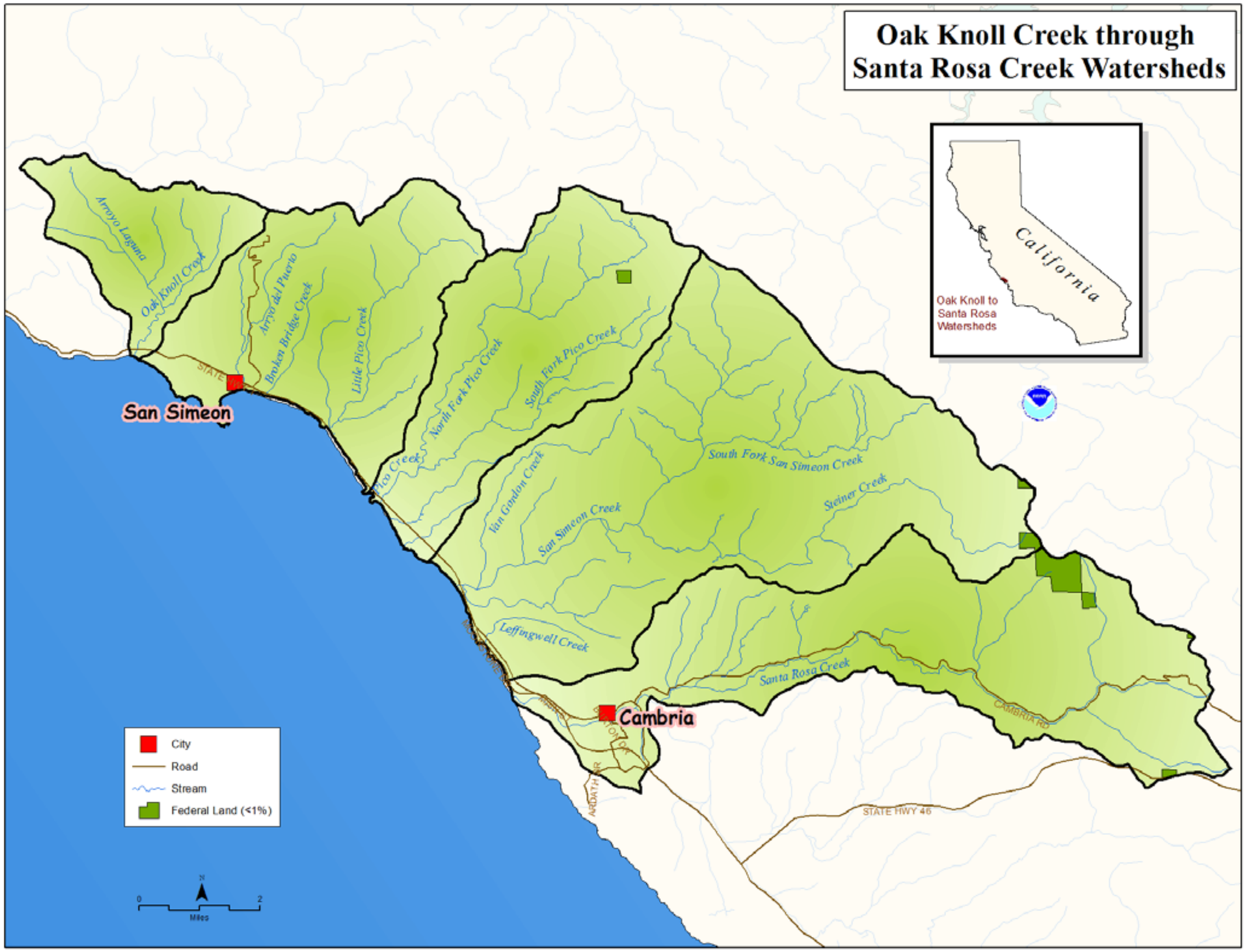

Figure 12-3. Federal and Non-Federal Land Ownership within the Oak Knoll Creek through the Santa Rosa Creek Watersheds.

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

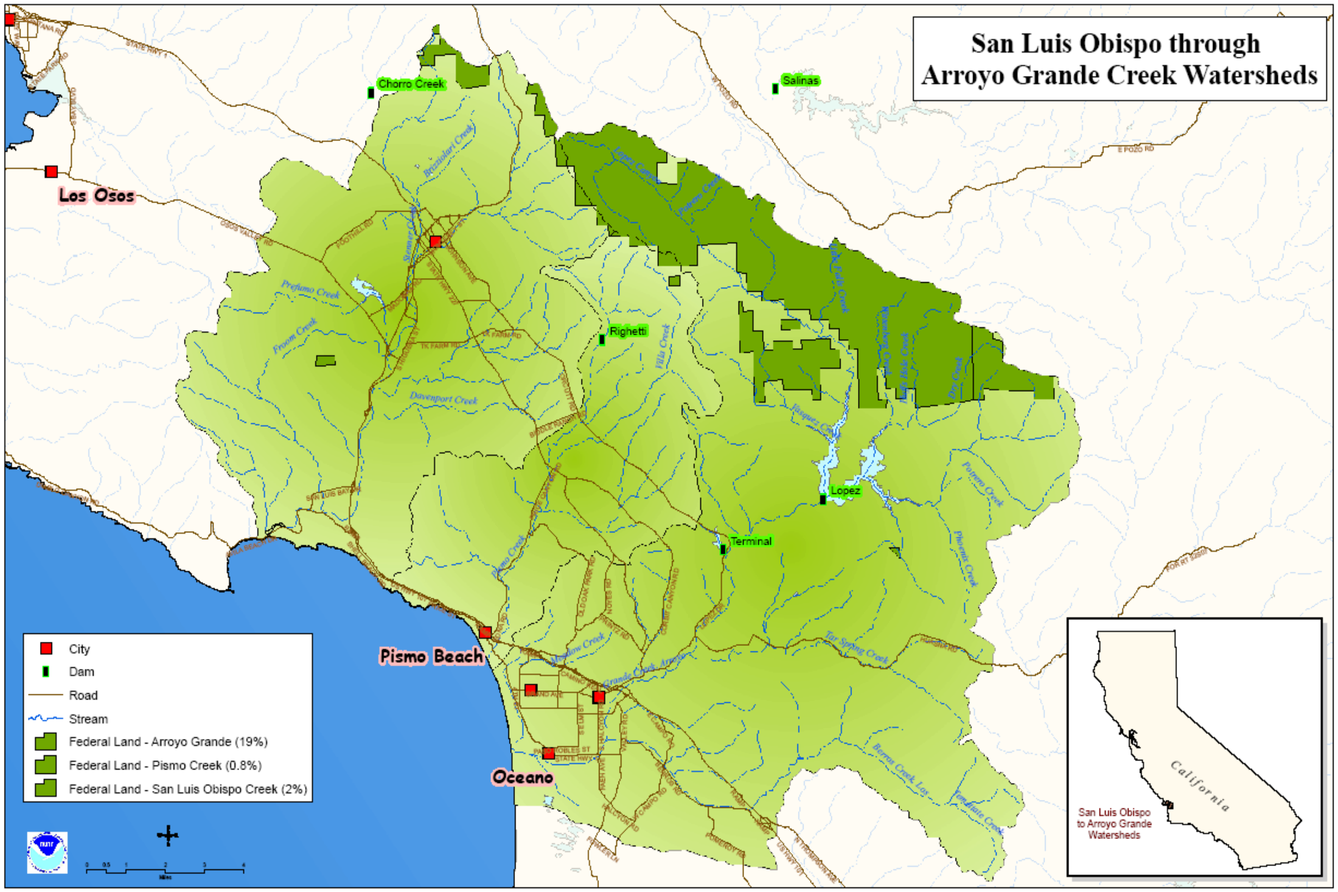

Figure 12-5. Federal and Non-Federal Land Ownership within the San Luis Obispo through the Arroyo Grande Creek Watersheds.

12.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for 12 watersheds and sub-watersheds in the San Luis Obispo Terrace BPG chosen from those identified by the TRT, with the focus on conditions most directly relevant to steelhead. 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.

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, though the presence of limited agricultural operations (including grazing) have impacted some watersheds in this BPG. (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008b, Watson *et al.* 2008, California Conservation Corps 2005, Nelson *et al.* 2005a, 2005b, Jones and Stokes and Cambria Forest Committee, 2002, Wurster *et al.* 2002, Stephenson and Calcarone 1999, Nelson 1994, Jones and Stokes 1985, 1981, California Department of Water Resources 1978, Knable 1978).

The southern portion of the San Luis Obispo Terrace BPG is developed with a number of urban communities, including San Simeon, Cambria, Avila, and the Cities of San Luis Obispo, Pismo Beach, Grover Beach, and Arroyo Grande. Many of the lower or middle reaches of the steelhead bearing streams in the southern portion of the San Luis Obispo Terrace BPG run through developed communities and have been impacted by urbanization; these impacts include encroachment into the riparian corridor, channelization of the natural stream bottom and banks, various fish passage impediments at road crossings (as well as flood control structures and water diversions), and impacts to water quality from both urban runoff, and increased sedimentation stemming from road and hill, and in some cases, agricultural development.

Arroyo Grande Creek

There are also a number of dams in the southern portion of the San Luis Obispo Terrace BPG (*e.g.*, Whale Rock, Chorro Creek, and Lopez dams) which impact steelhead by limiting access to upstream spawning and rearing habitats and modifying the natural pattern of flow (and related sandbar breaching at the estuaries). As noted above, reservoirs associated with these dams can also act as refugia for non-native warm water species (Hunt & Associates 2008a, Kier Associates and National Marine Fisheries Service 2008a, 2008b).

See Figure 12-6 for an overview of the dams and other fish passage impediments within the Carmel River Basin BPG, but note the status of fish passage impediments is in flux, with old impediments being removed or modified, while new impediments may be installed, or discovered through updated inventories; a current list of fish passage impediments can be found on the California Department of Fish and Wildlife website: http//www.cafishpassageforum.org/

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 threats 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. The 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).

San Simeon Creek

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 lower floodplain of San Simeon Creek, thereby concentrating land-use impacts in this area. The stream and riparian corridor are subject to a number of 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.

A wastewater discharge program via a groundwater infusion program within the lower San Simeon groundwater basin has potential to modify both ground and surface water levels and water quality (Harrington *et al.* 1997, Bein and Frost & Associates 1991a, 1991b, Jones and Stokes 1991, Matthews & Associates 1990, 1991, McClelland Engineers 1998). A proposed desalination plant and associated groundwater withdrawals adjacent to the Santa Rosa Creek estuary have the potential to adversely affect the lower stream reaches and estuary by periodically reducing the groundwater table that contributes to and maintains estuarine water levels, particularly during the summer when the sandbar closes the estuary off to the ocean; however, the final design of this facility has not been determined, and the precise nature and scope of any potential impacts have not been established (Cooley and Donnelly 2012, Fryer 2012, California Coastal Commission 2010, Advanced Geoscience, Inc. 2008, Cambria Community Services District 2008, 1994, D. W. Kelley & Associates 2008, 2006a, 2006b, 2001, California Department of Water Resources 2003).

Pismo Creek Estuary - Storm Drain

Development of recreational facilities at the mouth of the San Simeon Creek (San Simeon State Park) and the placement of the Highway 1 bridge abutments has eliminated 50 percent of the estuary. (Kier Associates and National Marine Fisheries Service 2008b; see also, D. W. Alley & Associates, 1997a, 1993, 1992a, Nelson *et al*. 2005b).

Fourteen anthropogenic activities ranked as the top five sources of threats to anadromous *O. mykiss* viability in the San Luis Obispo Terrace BPG (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, with less than 10 percent of any watershed converted to agricultural production, watersheds south of San Simeon Creek (*e.g.,* Santa Rosa, Cayucos, San Luis Obispo, and Arroyo Grande Creeks) share a common pattern of urban and agricultural development that 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, and placement of roads in or near the riparian corridor, and the growth of towns and cities on the floodplains, frequently at or near the estuaries. Other important sources of threats to anadromous *O. mykiss* in this BPG include: sedimentation, substrate embeddedness, excessive groundwater extraction, numerous culverts and road crossings that act as passage barriers, recreational facilities, non-point pollution as well as nutrient and coliform bacteria loading from agricultural and wastewater treatment effluents, and stream 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.

Arroyo Grande Creek – Lopez Dam

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 *et al.* 2006). The reservoirs behind these also 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 or vectors for the transmission of disease).

Arroyo del Corral Creek Estuary – Juvenile Northern Elephant Seals

Non-native fishes, crayfish, and/or amphibians also occur in the mainstems of the many watersheds in the San Luis Obispo Terrace BPG (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, 2006a, 2006b, 2001, 1997c, 1996, Rischbieter 2008, 2007, 2006, 2004, The Land Conservancy of San Luis Obispo County 2008, Allen 2007, 2001, D. W. Kelley & Associates 2007, 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 2006, 2005, 2003, Stark and Wilkison 2002, Otte and McEwan 2001, Yates 1998, Cleveland 1995, Leggett 1994, Nelson 1994b, Prunuske Chatham Inc. 1993, Rathbun *et al.* 1993, 1991a, 1991b, Russell 1990, 1991).

A newly emerging potential issue is the expansion of some marine mammal populations (*e.g.*, Northern elephant seals *Mirounga angustirostris* at Piedras Blancas near San Simeon) which seasonally gather near several small estuaries where juvenile steelhead rear.

San Luis Obispo Creek – Marre Dam

The interactions, if any, between Northern elephant seals and steelhead has not been the subject of any systematic investigation within the SCCCS DPS and its significance is therefore unknown; however, juveniles Northern elephant seals are not known to pursue prey prior to entering the marine environment. Marine mammals are protected under the Marine Mammals Protection Act of 1972 (MMPA), and their management is subject to the provisions of the MMPA (National Marine Fisheries Service 2011, Steele and Anderson 2006, Middlemas *et al*. 2005, Hinton 2003, Yurk and Trites 2000, Lowry 2002, Le Boeuf 1996, Lowry *et al.* 1987, 1996, Le Boeuf 1996, Fresh 1997, Le Boeuf and Laws 1994, Antonelis *et al.* 1994, Stewart *et al.* 1994, Stewart and Huber 1993, United State General Accounting Office, 1993, Beddington *et al.* 1985, DeMaster *et al.* 1985, Cooper 1983, Reiter *et al.* 1978, Radford *et al.* 1965).

Little Pico Creek

The original areal extent of the Pico, San Simeon, Santa Rosa, Morro, San Luis Obispo, Pismo, and Arroyo Grande Creek estuaries has been reduced between 50 and 80 percent as a result of development of recreational facilities (*e.g.,* State and County parks), Highway 1 bridge construction, and/or agricultural or urban development (Kier Associates and National Marine Fisheries Service 2008b, Wurster *et al.* 2000, Ferren *et al.* 1995, Gerdes *et al.* 1994, Dahl 1990).

Pismo Creek Estuary

Fires have been relatively minor source of disturbance in the northern watersheds of the San Luis Obispo Terrace BPG 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, Chorro, Los Osos, San Luis Obispo, Pismo, and Arroyo Grande Creek watersheds to the south have burned over this period. Increased road density and human population density in these fire-prone watersheds has served to increase fire frequency. Sedimentation and increased substrate embeddedness resulting from overgrazing and agricultural developments are also significant habitat stressors in these watersheds.

Finally, the spread of exotic and invasive species, including plant species, continues to increase with the increasing human population and related changes in land uses within the San Luis Obispo Terrace BPG; for example, Pampas Grass (*Cortaderia jubata*) along the northern coast of the San Luis Obispo Terrace BPG is extensive, and has the potential to invade most of the watersheds within the BPG. Reservoirs associated with dams can also act as refugia for non-native warm water species. The early detection, rapid response to, and preferably prevention of, these introductions is an important component in any comprehensive steelhead recovery effort within the San Luis Coast Terrace BPG.

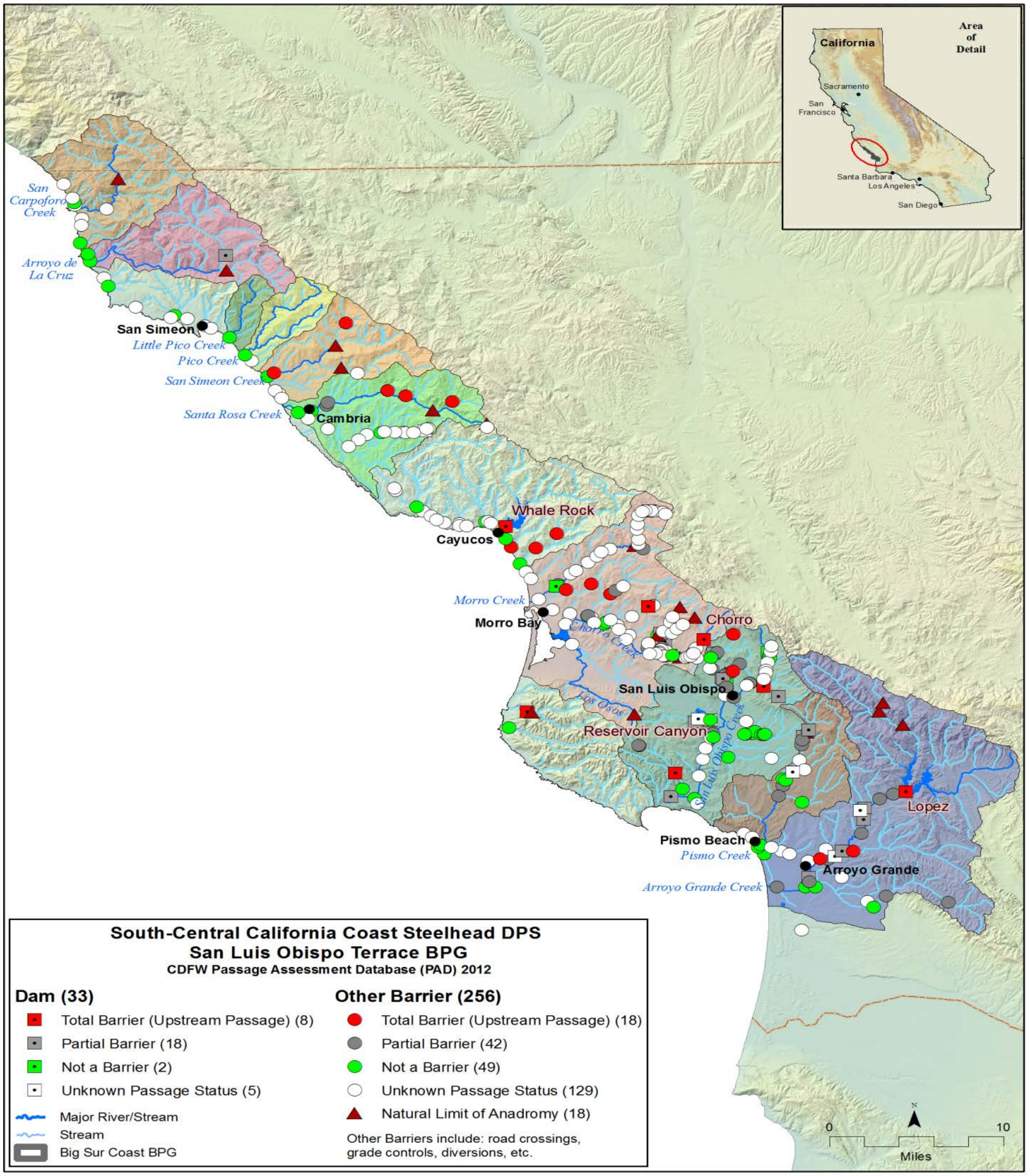

Figure 12-6. Major Fish Passage Impediments, San Luis Obispo Terrace BPG. Note: the status of fish passage impediments is in flux, with existing one being removed or modified, while new ones may be installed, or discovered through updated inventories; a current inventory of fish passage impediments can be found on the California Department of Fish and Wildlife website: http://www.cafishpassageforum.org/

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	Red	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	Yellow	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	Light green	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 threa

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, Arroyo de la Cruz, Little Pico, 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 developments and agricultural operations. Additionally, conditions could change in the future because much land in San Luis Obispo Terrace BPG 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, Pismo, and Arroyo Grande Creeks 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, 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.

San Carpoforo Creek Steelhead – 1970

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 guide specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the recovery actions or to target additional recovery actions as part of any recovery strategy for the San Luis Obispo Terrace BPG.

Management of the steelhead populations of the San Luis Obispo Terrace BPG will require additional investigations of the population structure of the BPG; these studies should include, but not be limited to, the role of the various individual watersheds in the maintenance of the BPG as a whole (including dispersal rates between watersheds and the relationship between the anadromous and non-anadromous forms of *O. mykiss*), how these individual populations contribute to the diversity of the BPG, and the role and use of the estuaries by steelhead, particularly rearing juveniles. The San Carpoforo and Arroyo de la Cruz Creek watersheds are south of the southernmost extent of coast redwoods and exhibit a suit of watershed characteristics (fire-prone chaparral dominated vegetation, highly erosive soils, flashy, intermittent and perennial stream flows, moderated by coastal climate, and a seasonally closed estuary). These features combined with their relatively unimpaired condition and the protection afforded by the watersheds' inclusion in public lands (U.S. Forest and State Parks) and conservation easements, makes them ideally suited for long-term ecological and population investigations (Capelli 2013).

Table 12-3 below highlights critical Recovery Actions recovery actions for the San Luis Obispo Terrace BPG. The following Tables 12-4 through 12-10 describe and prioritize recovery actions for each watershed in the San Luis Obispo Terrace BPG. These tables also provide provisional cost estimates 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	Develop and 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, including management of the artificial breaching of the creek's mouth.
Santa Rosa Creek	Develop and 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, including management of the artificial breaching of the creek's mouth.
San Luis Obispo Creek	Develop and 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, including management of the artificial breaching of the creek's mouth.
Pismo Creek	Develop and 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	Develop and 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, including management of the artificial breaching of the creek's mouth.

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, Chapter 6, Section 6.4, for a discussion of Recovery Action Ranks, and Chapter 3, Section 3.0, for a description of Listing Factors. See Appendix E for a discussion of recovery action cost estimates.

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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	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 Carpoforo Creek												
ScP-SCCC S-1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2B	5	47520	0	0	0	0	47520
ScP-SCCC S-1.2	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2B	5	0	0	0	0	0	0
ScP-SCCC S-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Effluents	1, 4	3B	100	0	0	0	0	0	0
ScP-SCCC S-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	2A	5	91850	0	0	0	0	91850
ScP-SCCC S-4.2	Provide fish passage around dams and diversions	NMFS, USFS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	3A	5	0	0	0	0	0	0
ScP-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TCFT TBSLT, VWA, TCFT, TU	Groundwater Extraction	1, 4	2A	5	91850	0	0	0	0	91850
ScP-SCCC S-6.2	Develop and implement groundwater monitoring and management program (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Groundwater Extraction	1, 4	3B	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
ScP-SCCC S-9.2	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, TBSLT SLOCFB,, VWA, TCFT, TU	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
ScP-SCCC S-9.3	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, TBSLT, SLOCFB, VWA, TCFT, TU	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
ScP-SCCC S-9.1	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW SLOCFB, TCLT, TBSLT, VWA, TCFT, TU	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
ScP-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 U.S. Forest Service Plan for the Silver Peak Wilderness Area)	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, TCFT	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
ScP-SCCC S-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, SLOCFB, TCLT, TBSLT, VWA, TCFT, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
ScP-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, USFS, CDOT, SLOC, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Roads	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
ScP-SCCC S-11.2	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, USFS, CDOT, SLOCFB, SLOC, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Roads	1, 4	3B	20	0	0	0	0	0	0
ScP-SCCC S-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	4154000	0	0	0	0	4154000
ScP-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, SLOC, NMFS, CDFW, LPFW, SLOCFB, TCLT, TBSLT, VWA, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
ScP-SCCC S-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, NMFS, SLOCFB, CDFW, TCLT, TBSLT, VWA, TCFT	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
ScP-SCCC S-14.1	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCB, SWRCB, SLOC, NMFS, CDFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
ScP-SCCC S-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP. USFS, USFWS, SLOC, NMFS, CDFW, LP SLOCFB, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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	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 de la Cruz												
AC-SCCC S-1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2A	5	47520	0	0	0	0	47520
AC-SCCC S-1.2	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2A	5	0	0	0	0	0	0
AC-SCCC S-1.3	Develop, adopt and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2A	20	0	0	0	0	0	0
AC-SCCC S-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, TU	Agricultural Effluents	1, 4	3A	100	0	0	0	0	0	0
AC-SCCC S-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFW, SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
AC-SCCC S-4.2	Develop and implement water management plan for dam operations	NMFS, USFS, CDFW,SLOC, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
AC-SCCC S-4.3	Provide fish passage around dams and diversions	NMFS, USFS, CDFW,SLOC SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	2A	5	0	0	0	0	0	0
AC-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Groundwater Extraction	1, 4	2A	5	91850	0	0	0	0	91850
AC-SCCC S-6.2	Develop and implement groundwater monitoring and management program (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, LPFW, TCLT, SLOCFB, TBSLT, VWA, TCF, TUT	Groundwater Extraction	1, 4	2A	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
AC-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, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
AC-SCCC S-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
AC-SCCC S-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	2B	20	76140	76140	76140	76140	0	304560
AC-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)	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
AC-SCCC S-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
AC-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, USFS, CDOT, SLOC, CDPR, CDFW, LPFW, TCLT, TBSLT, SLOCFB, VWA, TCFT, TU	Roads	1, 4	2B	20	0	0	0	0	0	0
AC-SCCC S-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, CDPR, CDFW, LPFW, TCLT, TBSLT, SLOCFB, VWA, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1742000	0	0	0	0	174200

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
AC-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	CCCOM, SLOC, NMFS, CDFW, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
AC-SCCC S-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, NMFS, CDFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
AC-SCCC S-14.2	Review, assess and modify if necessary all NPDES wastewater discharge permits	RWQCB, SWRCB, SLOC, SLOCFB, NMFS, CDFW, TCLT, TBSLT, VWA, TCFT, TU	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
AC-SCCC S-15.1	Develop and implement an integrated wildlands fire and hazardous fuels plan	CDF&FP. USFS, USFWS, SLOC, SLOCFB, NMFS, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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	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
Little Pico Creek												
LP-SCCCS -1.1	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE, CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2B	5	47520	0	0	0	0	47520
LP-SCCCS -1.2	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE, CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2B	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, SLOCFB, CCRCDC, CCSE, CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2B	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, SLOCFB, CCRCDC, CCSE, CSLRDC, LPFW, TCLT, TBSLT, TU	Agricultural Effluents	1, 4	2B	100	0	0	0	0	0	0
LP-SCCCS -4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	2A	5	91850	0	0	0	0	91850
LP-SCCCS -4.2	Develop and implement water management plan for dam operations	NMFS, USFS, CDFW, SLOC SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Dams and Surface Water Diversions	1, 3, 4	2B	5	91850	0	0	0	0	91850
LP-SCCCS -3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFW, CCCON, SLOC, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	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, CDFW, CCCON, SLOC, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Culverts and Road Crossings (Passage Barriers)	1, 3, 5	2A	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
LP-SCCCS-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
LP-SCCCS-6.2	Develop and implement groundwater monitoring and management program (or review and update)	NMFS, USFS, USGS, CDFW, SLOC SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	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, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	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, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	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, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
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, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	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, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	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	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT,	Roads	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
	abandoned roadways	VWA, TCFT, TU										
LP-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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, SLOCFB, NMFS, CDFW, TCLT, TBSLT, VWA, TCFT, TU	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, SLOCFB, NMFS, CDFW, TCLT, TBSLT, VWA, TCFT, TU	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, CDFW, TCLT, TBSLT, VWA, TCFT, TU	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
LP-SCCCS-15.1	Develop and implement an integrated wildlands fire and hazardous fuels plan	CDF&FP. USFS, USFWS, SLOC, SLOCFB, NMFS, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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	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
Pico Creek												
PC-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE, CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2B	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, SLOCFB, CCRCDC, CCSE, CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2B	5	47520	0	0	0	0	47520
PC-SCCCS-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE, CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	2B	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, SLOCFB, CCRCDC, CCSE, CSLRDC, LPFW, TCLT, TBSLT, TU	Agricultural Effluents	1, 4	2B	100	0	0	0	0	0	0
PC-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment	NMFS, CDFW, CCCON, SLOC, SLOCFB, 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, CDFW, CCCON, SLOC, TBSLT, VWA, CCSE, TCFT, TU	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, CDFW,SLOC, LPFW, TCL, TBSLT, VWA, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	3B	5	91850	0	0	0	0	91850

PC-SCCC S-4.2	Develop and implement water management plan for dam operations	NMFS, USFS, CDFW,SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Dams and Surface Water Diversions	1, 3, 5	1B	5	91850	0	0	0	0	91850
PC-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW,SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Groundwater Extraction	1, 4	3B	5	91850	0	0	0	0	91850
PC-SCCC S-6.2	Develop and implement groundwater monitoring and management program (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Groundwater Extraction	1, 4	3B	10	254350	39775	0	0	0	294125
PC-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, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
PC-SCCC S-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	3B	100	0	0	0	0	0	0
PC-SCCC S-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	3B	20	76140	76140	76140	76140	0	304560
PC-SCCC S-10.1	Review and modify development and management plans for recreational areas and national forests	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	Recreational Facilities	1, 2 , 3, 4, 5	3B	20	0	0	0	0	0	0
PC-SCCC S-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
PC-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Roads	1, 4	3B	20	0	0	0	0	0	0
PC-SCCC S-12.1	Develop and implement an estuary restoration and	USFS, USFWS, NMFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT,	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	2345000	0	0	0	0	2345000

	management plan	VWA, CCSE, TCFT, TU										
PC-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, NMFS, CDFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	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, CDFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	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, CDFW, TCLT, SLOCFB, TBSLT, VWA, TCFT, TU	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, CDFW, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	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	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 Simeon Creek												
SS-SCCC S-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	1B	20	0	0	0	0	0	0
SS-SCCC S-1.2	Manage livestock grazing to maintain or restore aquatic habitat functions	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
SS-SCCC S-1.3	Manage agricultural development and restore riparian zones	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Agricultural Development	1, 4	1B	5	0	0	0	0	0	0
SS-SCCC S-2.1	Develop and implement plan to minimize runoff from agricultural activities	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT	Agricultural Effluents	1, 4	2B	100	0	0	0	0	0	0
SS-SCCC S-3.1	Conduct watershed-wide fish passage barrier assessments (or review and update)	NMFS, CDFW, CCCON, SLOC, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Culverts and Road Crossings (Passage Barriers)	1, 4	2B	5	96690	0	0	0	0	96690
SS-SCCC S-3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed (*e.g.,* San Luis Obispo County	NMFS, CDFW, CCCON, SLOC, TBSLT, VWA, CCSE, TCFT	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
	Stream Crossing Inventory and Fish Passage Evaluation, 2005)											
SS-SCCC S-4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	3B	5	91850	0	0	0	0	91850
SS-SCCC S-4.3	Provide fish passage around dams and diversions	NMFS, USFS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, TCFT, TU	Dams and Surface Water Diversions		1B	5	0	0	0	0	0	0
SS-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC SLOCFB,, LPFW, TCLT, TBSLT, VWA, CCES,TCFT, TU	Groundwater Extraction	1, 4	1A	5	91850	0	0	0	0	91850
SS-SCCC S-6.2	Develop and implement groundwater monitoring and management program (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Groundwater Extraction	1, 4	1A	10	254350	39775	0	0	0	294125
SS-SCCC S-7.1	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFW, SLOC, SLOCFB, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
SS-SCCC S-7.2	Develop and implement a stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFW, SLOC, SLOCFB, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
SS-SCCC S-8.1	Review and modify mining operations (*e.g.,* using guidance in Cluer 2004)	USGS, NMFS, CDFW, CDMG, SLOC, SLOCFB, CCRCDC, CSLRCD, NRCS,	Mining and Quarrying	1, 3, 5	1B	20	68030	0	0	0	0	68030

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
		CCSE, TCFT										
SS-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, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, CCSE, TBSLT, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
SS-SCCC S-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, CCSE, VWA, CCSE, TCFT, TU	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
SS-SCCC S-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, CCSE, VWA, CSSE, TCFT, TU	Non-Native Species	1, 3, 5	2B	20	76140	76140	76140	76140	0	304560
SS-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, San Simeon State Beach Management Plan)	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	0	0	0	0	0	0
SS-SCCC S-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	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 21-25	FY 1-100
SS-SCCC S-11.1	Manage roadways and adjacent riparian corridor and restore abandoned roadways	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, CDPR, CDFW, LPFW, TCLT, TBSLT, SLOCFB, VWA, CCSE, TCFT, TU	Roads	1, 4	1B	20	0	0	0	0	0	0
SS-SCCC S-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Roads	1, 4	1B	20	32260	32260	32260	32260	0	129040
SS-SCCC S-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Roads	1, 4	1B	20	0	0	0	0	0	0
SS-SCCC S-12.1	Develop and implement an estuary restoration and management plan	USFS, USFWS, NMFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	1675000	0	0	0	0	1675000
SS-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, NMFS, CDFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
SS-SCCC S-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, SLOCFB, NMFS, CDFW, TCLT, TBSLT, VWA, CCSE,TCFT, TU	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
SS-SCCC S-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, SLOCFB, NMFS, CDFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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
SS-SCCC S-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable stormwater permits	RWQCB, SWRCB, SLOCFB, SLOC, NMFS, CDFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
SS-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, CDFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Urban Effluents	1, 4	3B	20	0	0	0	0	0	0
SS-SCCC S-15.1	Develop and implement an integrated wildlands fire and hazardous fuels plan	CDF&FP. USFS, USFWS, SLOC, SLOCFB, NMFS, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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	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
Santa Rosa Creek												
SR-SCCCS -1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	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, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	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, SLOCFB, CCRCDC, CCSE. CSLRDC, LPFW, TCLT, TBSLT, VWA, TCFT, TU	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, SLOCFB, CCRCDC, CCSE, CSLRDC, CCSE, TCFT, TU	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
SR-SCCCS -3.1	Conduct watershed-wide fish passage barrier assessment (or review and update)	NMFS, CDFW, CCCON, SLOC, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
SR-SCCCS -3.2	Develop and implement plan to remove or modify fish passage barriers within the watershed (*e.g.,* San Luis Obispo County Stream Crossing Inventory and Fish Passage Evaluation, 2005)	NMFS, CDFW, CCCON, SLOC, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Culverts and Road Crossings (Passage Barriers)		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
SR-SCCCS -4.1	Develop and implement water management plan for diversion operations	NMFS, USFS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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, SLOCFB, USGS, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Flood Control Maintenance	1, 4	1B	5	68030	0	0	0	0	68030
SR-SCCCS -6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
SR-SCCCS -6.2	Develop and implement groundwater monitoring and management plan (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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, CDFW SLOC, SLOCFB, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
SR-SCCCS -7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFW SLOC, SLOCFB, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
SR-SCCCS -7.3	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFW SLOC, SLOCFB, CCRCDC, CSLRCD, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Levees and Channelization	1, 4	2A	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
SR-SCCCS-9.1	Develop and implement watershed-wide plan to assess the impacts of non-native species and develop control measures	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, CCSE, VWA, TCFT, TU	Non-Native Species	1, 3, 5	2B	100	0	0	0	0	0	0
SR-SCCCS-9.2	Develop and implement non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, CCSE, VWA, TCFT, TU	Non-Native Species	1, 3, 5	2B	20	76140	76140	76140	76140	0	304560
SR-SCCCS-9.3	Develop and implement public education program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, SLOCFB, TBSLT, CCSE, VWA,TCFT, TU	Non-Native Species	1, 3, 5	2B	20	0	0	0	0	0	0
SR-SCCCS-10.1	Review and modify development and management plans for recreational areas and national forests (*e.g.*, Shamel County Park)	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT SLOCFB,, TBSLT, VWA, CCSE, TCFT, TU	Recreational Facilities	1, 2, 3, 4, 5	2B	20	76140	76140	76140	76140	0	304560
SR-SCCCS-10.2	Develop and implement a public educational program on watershed processes	USFWS, USFS, NMFS, CDFW, CDPR, CNPS, LPFW, TCLT, TBSLT, VWA SLOCFB,, CCSE, TCFT, TU	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, CDFW, USFS, CDOT, SLOC, CDPR, CDFW, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	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, CDFW, USFS, CDOT, SLOC, CDPR, CDFW, LPFW, TCLT, SLOCFB, TBSLT, VWA, CCSE, TCFT, TU	Roads	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
SR-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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, SLOCFB, CDPR, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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, SLOCFB, NMFS, CDFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
SR-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, NMFS, CDFW, TCLT, TBSLT, VWA, CCSE,TCFT, TU	Urban Development	1, 4	2B	20	0	0	0	0	0	0
SR-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, NMFS, CDFW, TCLT, TBSLT, VWA, CCSE,TCFT, TU	Urban Development	1, 4	2B	20	0	0	0	0	0	0
SR-SCCCS-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, SLOCFB, NMFS, CDFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
SR-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, SLOCFB, NMFS, CDFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	Urban Effluents	1, 4	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
SR-SCC-15.1	Develop and implement an integrated wildland fire and hazardous fuel management plan	CDF&FP. USFS, USFWS, SLOC, SLOCFB, NMFS, CDFW, LPFW, TCLT, TBSLT, VWA, CCSE, TCFT, TU	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	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
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, SLOCFB, CCRCDC, CCSE, CSLRDC, TCLT, CCSE, TCFT, MBNEP, TU	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, SLOCFB, CCRCDC, CCSE, CSLRDC, TCLT, CCSE, TCLT, MBNEP, TU	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, SLOCFB, CCRCDC, CSLRDC, CCSE, TCFT, MBNEP, TU	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
MC-SCCCS-3.1	Conduct a watershed-wide fish passage barrier assessment (or review and update)	NMFS, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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 (*e.g.,* San Luis Obispo County Stream Crossing Inventory and Fish Passage Evaluation, 2005)	NMFS, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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
MC-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
MC-SCCCS-4.2	Provide fish passage around dams and diversions	NMFS, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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, SLOCFB, USGS, CDFW, CCSE, TCFT, MBNEP, TU	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
MC-SCCCS-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
MC-SCCCS-6.2	Develop and implement groundwater monitoring and management program or review and update)	NMFS, USFS, USGS, CDFW, SLOC, CCSE, TCFT, MBNEP, TU	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, CDFW SLOC, SLOCFB, CCRCDC, CSLRCD, CCSE, TCFT, MBNEP, TU	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, CDFW SLOC, SLOCFB, CCRCDC, CSLRCD, CCSE, TCFT, MBNEP, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	Non-Native Species	1, 3, 4	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
MC-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	Non-Native Species	1, 3, 4	2B	100	0	0	0	0	0	0
MC-SCCCS-9.3	Develop and implement a public educational program on non-native species impacts	USFWS, USFS, NMFS, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5,	1A	5	2144000	0	0	0	0	2144000

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
MC-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
MC-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
MC-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP	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, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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 SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, LPFW, CCSE, TCFT, MBNEP, TU	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	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
Chorro Creek												
CC-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards (*e.g.*, Livestock and Land Program)	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE, CSLRDC, TCLT, CCSE, TCFT, MBNEP, TU	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 (*e.g.,* Livestock and Land Program)	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE, CSLRDC, TCL, CCSE, TCFT , MBNEP, TU	Agricultural Development	1, 4	1B	5	47520	0	0	0	0	47520
CC-SCCCS-1.3	Manage agricultural development and restore riparian zones (*e.g.,* Livestock and Land Program)	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CCSE, CSLRDC, TCLT, CCSE, TCFT, MBNEP, TU	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 (*e.g.*, Livestock and Land Program)	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCRCDC, CSLRDC, CCSE, TCFT, MBNEP, TU	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
CC-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment (or review and update)	NMFS, CDFW, CCCON, SLOC, CCSE, TCFT, MBNEP, TU	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
CC-SCCCS-3.2	Develop and implement a plan to remove or modify fish passage barriers within the watershed (or review and update)	NMFS, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT , MBNEP, TU	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, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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, USGS, RWQCB, CDFW, CCSE, TCFT, MBNEP, TU	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
CC-SCCCS-6.1	Conduct groundwater extraction analysis assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, CCSE, TCFT, MBNEP, TU	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
CC-SCCCS-6.2	Develop and implement groundwater monitoring and management program (or review and update)	NMFS, USFS, USGS, RWQCB,CDFW, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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, CDFW SLOC, SLOCFB, CCRCDC, CSLRCD, CCSE, TCFT, MBNEP, TU	Levees and Channelizatio n	1, 4	2B	100	0	0	0	0	0	0
CC-SCCCS-7.2	Develop and implement stream bank and riparian corridor	NRCS, FEMA, NMFS, CDFW SLOC, SLOCFB, CCRCDC, CSLRCD,	Levees and Channelizatio n	1, 4	2B	5	10521940	0	0	0	0	10521940

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
	restoration plan	CCSE, TCFT, MBNEP, TU										
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, CDFW, CDPR, SLOCFB, CNPS, CCSE,TCFT, MBNEP, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, CDPR, CNPS, SLOCFB, CCSE, TCFT, MBNE, TUP	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	Roads	1, 4	1B	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
CC-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill or railroad lines and roads	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, CCSE,TCFT, MBNEP, TU	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
CC-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, SLOCFB, NMFS, CDFW, CCSE,TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, CCSE,TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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
CC-SCCCS-14.3	Review, assess and modify residential and commercial wastewater septic treatment facilities	RWQCB, SWRCB, SLOC, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, LPFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, CCRCDC, CCSE, CSLRDC, TCLT, CCSE, TCFT, MBNEP, TU	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, SLOCFB, CCRCDC, CCSE. CSLRDC, TCLT, CCSE, TCFT, MBNEP, TU	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, SLOCFB, CCRCDC, CSLRDC, CCSE, TCFT, MBNEP, TU	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
LO-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment (or review and update)	NMFS, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
LO-SCCCS-3.2	Develop and implement a plan to remove or modify passage barriers in the watershed (or review and update)	NMFS, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, TU	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, CDFW, CCCON, SLOC, CCSE, TCFT, MBNEP, TU	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
			Diversions									
LO-SCCCS-4.2	Develop and implement water management plan for dam operations	NMFS, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP	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, CDFW, CCCON, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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, SLOCFB, USGS, CDFW, CCSE, TCFT, MBNEP, TU	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
LO-SCCCS-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, RWQCB, CDFW, SLOC, SLOCFB, CCSE, TCFT, TU	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
LO-SCCCS-6.2	Develop and implement groundwater monitoring and management program (or review and update)	NMFS, USFS, USGS, RWQCB, CDFW, SLOC, SLOCFB, CCSE, TCFT, MBNEP, TU	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, CDFW SLOC, CCRCDC, CSLRCD, CCSE, TCFT, MBNEP, TU	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 minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFW SLOC, SLOCFB, CCRCDC, CSLRCD, CCSE, TCFT, MBNEP, TU	Levees and Channelization	1, 4	2B	100	0	0	0	0	0	0
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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	Non-Native Species	1, 3, 4	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
LO-SCCCS-9.2	Develop and implement a non-native species monitoring program	USFWS, USFS, NMFS, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, MBNEP, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	Roads	1, 4	2B	20	0	0	0	0	0	0
LO-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, CDPR, CDFWCCSE, TCFT, MBNEP, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	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
LO-SCCCS-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1B	5	62400	0	0	0	0	62400
LO-SCCCS-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, CCSE, TCFT, MBNEP, TU	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, SLOCFB, NMFS, CDFW, LPFW, CCSE, TCFT, MBNEP, TU	Wildfires	1, 4	2B	5	0	0	0	0	0	0

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	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 Luis Obispo Creek												
SLO-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, CCLO, CCRCDC, CCSE, CSLRDC, CCSE, TCFT, TU	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, SLOCFB, CCLO, CCRCDC, CCSE, CSLRDC, CCSE, TCFT, TU	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, SLOCFB, CCLO, CCRCDC, CCSE, CSLRDC, CCSE, TCFT, TU	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, SLOCFB, CSLO, CCRCDC, CSLRDC, CCSE, TCFT, TU	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
SLO-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment (or review and update)	NMFS, CDFW, CCCON, SLOC, CSLO, CCSE, TCFT, TU	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	NMFS, CDFW, CCCON, SLOC, SLOCFB, CSLO, CCSE, TCFT, TU	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
	Enhancement Plan, 2002)											
SLO-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFW, CCCON, SLOC, SLOCFB, CSLO, CCSE, TCFT, TU	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, CDFW, CCCON, SLOC, SLOCFB, CSLO, CCSE, TCFT, TU	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, CDFW, CCCON, SLOC, SLOCFB, 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, CDFW, CCSE, TCFT, TU	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
SLO-SCCCS-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, CSLO, CCSE, TCFT, TU	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 (or review and update)	NMFS, USFS, USGS, CDFW, 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, CDFW, SLOC, SLOCFB, CSLO, CCRCDC, CSLRCD, CCSE, TCFT, TU	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
SLO-SCCCS-7.2	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFW, SLOC, SLOCFB, CSLO, CCRCDC, CSLRCD, CCSE, TCFT, TU	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
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, CDFW, CDPR, CSLO, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, CSLO, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CSLO, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CSLO, CDFW, CCSE, TCFT, TU	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, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CSLO, CDFW, CCSE, TCFT, TU	Roads	1, 4	1B	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
SLO-SCCCS-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFW, USFS, CDOT, SLOC, SLOCFB, CDPR, CSLO, CDFW, CCSE, TCFT, TU	Roads	1, 4	1B	20	0	0	0	0	0	0
SLO-SCCCS-12.1	Develop and implement an estuary restoration and management plan	USFWS, NMFS, CDOT, SLOC, SLOCFB, CSLO, CDPR, CDFWCCSE, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	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, SLOCFB, NMFS, CDFW, 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, SLOCFB, NMFS, CDFW, CSLO, CCSE, TCFT, TU	Urban Development	1, 4	2B	5	62400	0	0	0	0	62400
SLO-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, SLOCFB, NMFS, CDFW, CSLO, CCSE, TCFT, TU	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, SLOCFB, CSLO, NMFS, CDFW, 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, SLOCFB, CSLO, NMFS, CDFW, CCSE, TCFT, TU	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
SLO-SCCCS-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP, USFS, USFWS, SLOC, SLOCFB, NMFS, CDFW, LPFW, CCSE, TCFT, TU	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	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
Pismo Creek												
Pis-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, COPB, CCRCDC, CCSE, CSLRDC, CCSE, TCFT, TU	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, SLOCFB, COPB, CCRCDC, CCSE, CSLRDC, CCSE, TCFT, TU	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, SLOCFB, COPB, CCRCDC, CCSE, CSLRDC, CCSE, TCFT, TU	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, SLOCFB, COPB, CCRCDC, CSLRDC, CCSE, TCFT, TU	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
Pis-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment (or review and update)	NMFS, CDFW, CCCON, SLOC, COPB, CCSE, TCFT, TU	Culverts and Road Crossings (Passage Barriers)	1, 4	1A	5	96690	0	0	0	0	96690
Pis-SCCCS-3.2	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, CDFW, CCCON, SLOC, SLOCFB, COPB, CCSE, TCFT, TU	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
Pis-SCCCS-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFW, CCCON, SLOC, SLOCFB, COPB, CCSE, TCFT, TU	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, CDFW, CCCON, SLOC SLOCFB,, COPB, CCSE, TCFT, TU	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, CDFW, CCCON, SLOC, SLOCFB, COPB, CCSE, TCFT, TU	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, SLOCFB, CPPB, USGS, CDFW, CCSE, TCFT, TU	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
Pis-SCCCS-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, 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 (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, COPB, CCSE, TCFT, TU	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, CDFW, SLOC, SLOCFB, COPB, CCRCDC, CSLRCD, CCSE, TCFT, TU	Levees and Channelization	1, 4	1B	100	0	0	0	0	0	0
Pis-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFW SLOC, COPB, CCRCDC, CSLRCD, CCSE, TCFT, TU	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940

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
Pis-SCCCS-7.3	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFW SLOC, SLOCFB,COPB, CCRCDC, CSLRCD, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CSLO, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CSLO, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CSLO, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, TU	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, CDFW, CDOT, SLOC, CDPR, SLOCFB, COPB, CDFW, CCSE, TCFT, TU	Roads	1, 4	1B	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
Pis-SCCCS-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFW, CDOT, SLOC, CDPR, SLOCFB, COPB, CDFW, CCSE, TCFT, TU	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, CDFW, CDOT, SLOC, CDPR, SLOCFB, COPB, CDFW, 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, SLOCFB, CDFW, CCSE, TCFT, TU	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, SLOCFB, COPB, NMFS, CDFW, CCSE, TCFT, TU	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, SLOCFB, NMFS, CDFW, COPB, CCSE, TCFT, TU	Urban Development	1, 4	1B	20	0	0	0	0	0	0
Pis-SCCCS-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, SLOCFB, NMFS, CDFW, COPB, CCSE,TCFT, TU	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, SLOCFB, NMFS, CDFW, COPB, CCSE, TCFT, TU	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, SLOCFB, COPB, NMFS, CDFW, CCSE, TCFT, TU	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
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, SLOCFB, COPB, NMFS, CDFW, 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, SLOCFB, NMFS, CDFW, LPFW, CCSE, TCFT, TU	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	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 Grande Creek												
AG-SCCCS-1.1	Develop, adopt, and implement agricultural land-use planning policies and standards	NRCS, BLM, NMFS, USFS, SLOC, SLOCFB, AG, CCRCDC, CCSE. CSLRDC, CCSE, TCFT, TU	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, SLOCFB, AG, CCRCDC, CCSE. CSLRDC, CCSE, TCFT, TU	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, SLOCFB, AG, CCRCDC, CCSE. CSLRDC, CCSE, TCFT, TU	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, SLOCFB, AG, CCRCDC, CSLRDC, CCSE,TCFT, TU	Agricultural Effluents	1, 4	1B	100	0	0	0	0	0	0
AG-SCCCS-3.1	Conduct watershed-wide fish passage barrier assessment (or review and update)	NMFS, CDFW, CCCON, SLOC, SLOCFB, AG, CCSE, TCFT, TU	Culverts and Road Crossings (Passage Barriers)			5	96690	0	0	0	0	96690
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, CDFW, CCCON, SLOC, SLOCFB, AG, CCSE, TCFT	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
AG-SCCC S-4.1	Develop and implement water management plan for diversion operations	NMFS, CDFW, CCCON, SLOC, SLOCFB, AG, CCSE, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
AG-SCCC S-4.2	Develop and implement water management plan for dam operations (*e.g.*, Lopez Dam)	NMFS, CDFW, CCCON, SLOC, SLOCFB, AG, CCSE, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	1A	5	91850	0	0	0	0	91850
AG-SCCC S-4.3	Provide fish passage around dams and diversions	NMFS, CDFW, CCCON, SLOC, SLOCFB, AG, CCSE, TCFT, TU	Dams and Surface Water Diversions	1, 3, 4	1A	10	TBD	TBD	TBD	TBD	TBD	TBD
AG-SCCC S-5.1	Develop and implement flood control maintenance program	ACOE, NMFS, NRCS, SLOC, SLOCFB, AG, USGS, CDFW, CCSE, TCFT, TU	Flood Control Maintenance	1, 4	1B	100	0	0	0	0	0	0
AG-SCCC S-6.1	Conduct groundwater extraction analysis and assessment (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, AG, CCSE, TCFT, TU	Groundwater Extraction	1, 4	1B	5	91850	0	0	0	0	91850
AG-SCCC S-6.2	Develop and implement a groundwater monitoring and management program (or review and update)	NMFS, USFS, USGS, CDFW, SLOC, SLOCFB, AG, CCSE, TCFT	Groundwater Extraction	1, 4	1B	10	254350	39775	0	0	0	294125
AG-SCCC S-7.1	Develop and implement plan to restore natural channel features	NRCS, FEMA, NMFS, CDFW SLOC, SLOCFB, AG, CCRCDC, CSLRCD, CCSE, TCFT, TU	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
AG-SCCCS-7.2	Develop and implement plan to vegetate levees and eliminate or minimize herbicide use near levees	NRCS, FEMA, NMFS, CDFW SLOC, SLOCFB, AG, CCRCDC, CSLRCD, CCSE, TCFT, TU	Levees and Channelization	1, 4	1B	5	10521940	0	0	0	0	10521940
AG-SC3S-7.3	Develop and implement stream bank and riparian corridor restoration plan	NRCS, FEMA, NMFS, CDFW SLOC, SLOCFB, AG, CCRCDC, CSLRCD, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, AG, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, AG, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR SLOCFB, AG, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, TU	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, CDFW, CDPR, SLOCFB, CNPS, CCSE, TCFT, TU	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, CDFW, CDOT, SLOC, SLOCFB, CDPR, AG, CDFW, CCSE, TCFT, TU	Roads	1, 4	1B	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
AG-SCCC S-11.2	Retrofit storm drains to filter runoff from roadways	USDOT, NMFS, CDFW, CDOT, SLOC, SLOCFB, CDPR, AG, CDFW, CCSE, TCFT, TU	Roads	1, 4	1B	20	0	0	0	0	0	0
AG-SCCC S-11.3	Develop and implement plan to remove or reduce approach-fill for railroad lines and roads	USDOT, NMFS, CDFW, CDOT, SLOC, SLOCFB, CDPR, AG, CDFW, CCSE, TCFT, TU	Roads	1,4	1B	5	6097000	0	0	0	0	6097000
AG-SCCC S-12.1	Develop and implement an estuary restoration and management plan	USFWS, NMFS, CDOT, SLOC, SLOCFB, AG, CDPR, CDFW, CCSE, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	1A	5	62400	0	0	0	0	62400
AG-SCCC S-12.2	Review and modify applicable County and/or City Local Coastal Plans	RWQCB, SWRCB, SLOC, SLOCFB, AG, NMFS, CDFW, CCSE, TCFT, TU	Upslope/Upstream Activities	1, 2, 3, 4, 5	2B	5	62400	0	0	0	0	62400
AG-SCCC S-13.1	Develop, adopt, and implement urban land-use planning policies and standards	CCCOM, SLOC, SLOCFB, NMFS, CDFW, AG, CCSE, TCFT, TU	Urban Development	1, 4	2B	20	0	0	0	0	0	0
AG-SCCC S-13.2	Retrofit storm drains in developed areas	CCCOM, SLOC, SLOCFB, NMFS, CDFW, AG, CCSE, TCFT, TU	Urban Development	1, 4	2B	5	398000	0	0	0	0	398000
AG-SCCC S-13.3	Develop and implement riparian restoration plan to replace artificial bank stabilization structures	CCCOM, SLOC, SLOCFB, NMFS, CDFW, AG, CCSE, TCFT, TU	Urban Development	1, 4	2B	20	0	0	0	0	0	0

Actio n #	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
AG-SCCC S-14.1	Review California Regional Water Quality Control Board Watershed Plans and modify applicable Stormwater Permits	RWQCB, SWRCB, SLOC, SLOCFB, AG, NMFS, CDFW, CCSE, TCFT, TU	Urban Effluents	1, 4	2B	20	0	0	0	0	0	0
AG-SCCC S-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, SLOCFB, AG, NMFS, CDFW, CCSE, TCFT, TU	Urban Effluents	1, 4	2B	100	0	0	0	0	0	0
AG-SCCC S-15.1	Develop and implement an integrated wildland fire and hazardous fuels management plan	CDF&FP, USFS, USFWS, SLOC, SLOCFB, NMFS, CDFW, LPFW, CCSE, TCFT, TU	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 SCCCS DPS will require a more complete understanding of the distinctive biology of steelhead within the SCCCS Recovery Planning Area. Additionally, it is 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 recovery efforts. These research and monitoring activities should run in parallel with the recovery actions identified in Chapters 8 through 12, and are in some cases are dependent upon increasing the number of returning fish. 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 TRT, to survey existing scientific information on steelhead ecology, and formulate a biological framework for a recovery plan for the SCCCS DPS (Boughton *et al.* 2007b, 2006, Boughton and Goslin 2006, Boughton *et al.* 2005, Boughton and Fish 2003; see also Clemento *et al.* 2009, Girman and Garza 2006).

The current state of knowledge of steelhead ecology is largely descriptive and qualitative. This has led to uncertainties in the viability framework, including the quantitative goals for distribution and abundance of steelhead and the strategy to achieve these goals. In general, the TRT approached uncertainty about recovery goals with a risk-averse, or precautionary, approach, consistent with accepted practices in conservation biology (McElhany *et al.* 2000). The TRT also recognized 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 potential benefits of pursuing such a program are a more effective and more-cost efficient recovery effort for steelhead.

Recovery of the SCCCS DPS will depend upon a quantitative framework addressing annual run size, along with year-to-year variability over the long term; and the quantitative response to specific recovery actions. These are related to the two overarching questions of steelhead recovery in the SCCCS Recovery Planning Area:

- ❑ 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 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 addresses two levels of biological organization, populations within the SCCCS DPS (*i.e.,* only the anadromous form), and the more encompassing Evolutionarily Significant Unit (ESU), which includes all life history forms. The *O. mykiss* populations 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 ESA. 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" 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 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 SCCCS Recovery Planning Area to be grouped into demographically independent populations. Generally, each discrete coastal watershed in the region was assumed (based on the species high fidelity to its natal streams) to have historically supported (at least) one demographically independent population of *O. mykiss* (See Appendix A for the definition of an independent population.) If migratory steelhead frequently move from one watershed to another, the one-watershed-one-population assumption may have some important exceptions (*e.g.,* in the small watersheds within the Big Sur Coast and San Luis Obispo Terrace BPGs). Interactions between populations from geographically proximate watersheds could have significant implications for recovery planning, including determining the annual run-size in individual watersheds necessary to constitute a viable population. As noted below several watersheds may support a metapopulation that could be considered as a single viable population for the purposes of meeting the DPS recovery criteria.

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: an independent population must exhibit a mean annual run size of at least 4,150 steelhead, including during periods of poor ocean conditions (such as occurred from the late 1970s through early 1990s). Additionally, the spawner densities need 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 extinction risk is less than 5% over 100 years. This criterion would use commonly accepted quantitative methods from conservation biology, *i.e.*, demographic data from the population in question.

Extinction risk is very sensitive to both annual run size and year-to-year variability. Due to this sensitivity 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, use of the prescriptive criteria ensures 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 less than 4,150 steelhead would perhaps be sufficient to ensure a low extinction risk. Including the performance-based viability criteria option, provides a mechanism for refining the viability criteria as more is learned over time.

Extinction risk for individual steelhead populations may also be sensitive to the influence of rainbow trout, particularity if the trout tend to stabilize or augment anadromous runs by 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 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 numeric criterion for independent population is set at 4,150 adult spawners per year. This criteria will be reviewed during NMFS's 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 are composed entirely of the anadromous form of O. mykiss, rather than a mixture of rainbow and steelhead. Nonetheless, the TRT also believed the criteria should cover the possibility that the beneficial effects of crossovers not only exists, but is necessary for viability of the listed species. This led to adoption of additional criteria specifying the anadromous and freshwater resident life history types should both be expressed in populations targeted in this recovery plan for them to be considered viable.

As noted, 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.

13.2.2 ESU/DPS-Level Criteria

The TRT outlined a set of ESU/DPS-level criteria, which, if met, would indicate that the SCCCS DPS 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,
- ❑ 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:

1. 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, and
2. to protect against catastrophic loss of entire populations due to disease, wildfires, 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 all the remaining core watersheds in the ecotype.

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-resistant refugia habitat) that are separated from one another by at least 42 miles (if possible), and should exhibit the three previously described life history types.

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), moist (transpiration), riparian shading, or by a coastal lagoon (via proximity to the ocean heat sink). As noted in Chapter 2, sparsely shaded higher elevation habitats can also produce higher water temperature conditions; conversely, lower, shaded habitats can produce cooler conditions. Lagoon water temperatures are also influenced by stratification of the water column driven by on and offshore winds.

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 patterns and did not reflect specific climate change drivers for which quantitative data at a regional scale is unavailable, but which could have a large impact on the region as discussed in Chapter 5, South-Central California Coast 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 redundancy was not a suitable strategy for protecting the species from the impacts of drought conditions. 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. Winter storms determine the power of high flow events that organize the distribution and extent of in-stream steelhead habitat (see further discussion in Chapter 7, Steelhead Recovery Strategy, section 7.5). 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 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. A key uncertainty is how to plan for climate change both at the level of the SCCCS Recovery Planning Area and individual watersheds.

13.3 RESEARCH FOCUS: ANADROMY, POPULATION STRUCTURE, AND MONITORING STEELHEAD RECOVERY

Steelhead habitats in the SCCCS Recovery Planning Area maintain a stochastic, dynamic equilibrium. This equilibrium involves dramatic processes such as floods and forest fires that disrupt habitat in the short term but ensure its continued existence over the long term by providing essential habitat features such as instream structure and spawning gravel. Other processes that influence the productivity of freshwater steelhead habitat, such as the severity of warm air temperatures during the dry season or the pattern of high-flow events during the wet season, may affect reproductive success by altering habitat suitability. 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 designing specific recovery actions. The research program supporting steelhead recovery in this region should focus on quantitative studies that: 1) identify ecological factors promoting both life history types of anadromy; 2) clarify key aspects of population structure; and 3) monitor progress toward recovery. Many of these research activities could be carried out at the life cycle monitoring stations described in the California Coastal Salmonid Population Monitoring Program (Adams *et al.* 2011; see also Table 13-1).

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 support 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 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 13-1, 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.

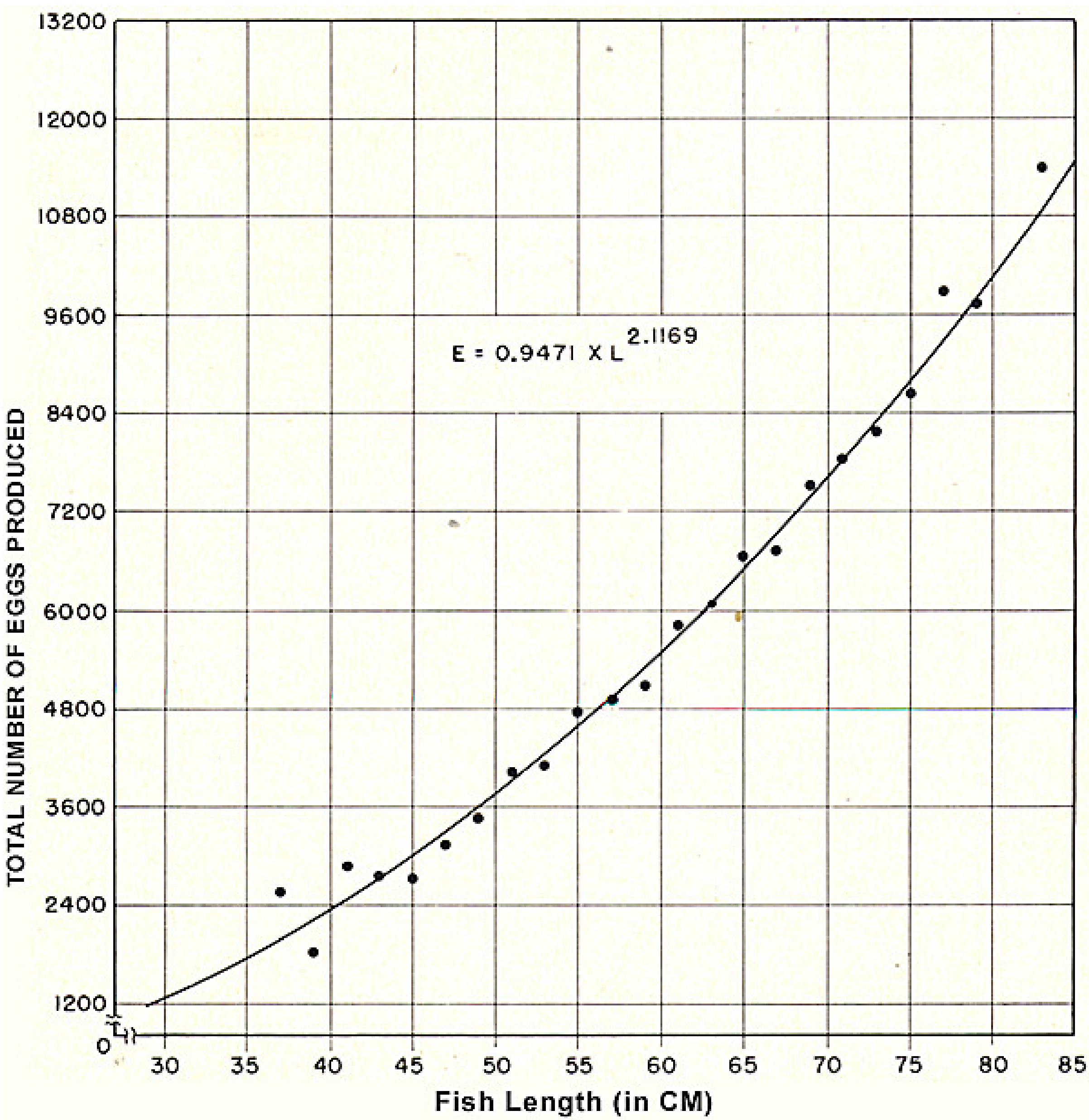


Figure 13-1. Fecundity as a function of body size for female steelhead sampled from Scott Creek in Santa Cruz County. Reproduced from Shapovalov and Taft (1954).

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 do not interbreed to a significant degree), over time the sea-going form should dominate any stream system with migration connectivity to the ocean. The resident forms would become confined to streams which lack migration connectivity to the Pacific Ocean. 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 the resident form is sometimes favored in anadromous waters. First, the migration corridor between the ocean and freshwater habitat is often 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 region, particularly in watersheds with deep interior populations, are clearly unreliable under current conditions. It is not clear 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 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 to inform management actions, for managed flow regimes, to maximize the protection and conservation of the species during critical migration and rearing periods.. 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). Growth opportunities in freshwater may significantly influence subsequent marine survival.

Figure 13-2, indicates that an outgoing smolt with 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%). 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 close to the northern boundary of the SCCCS DPS. 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.

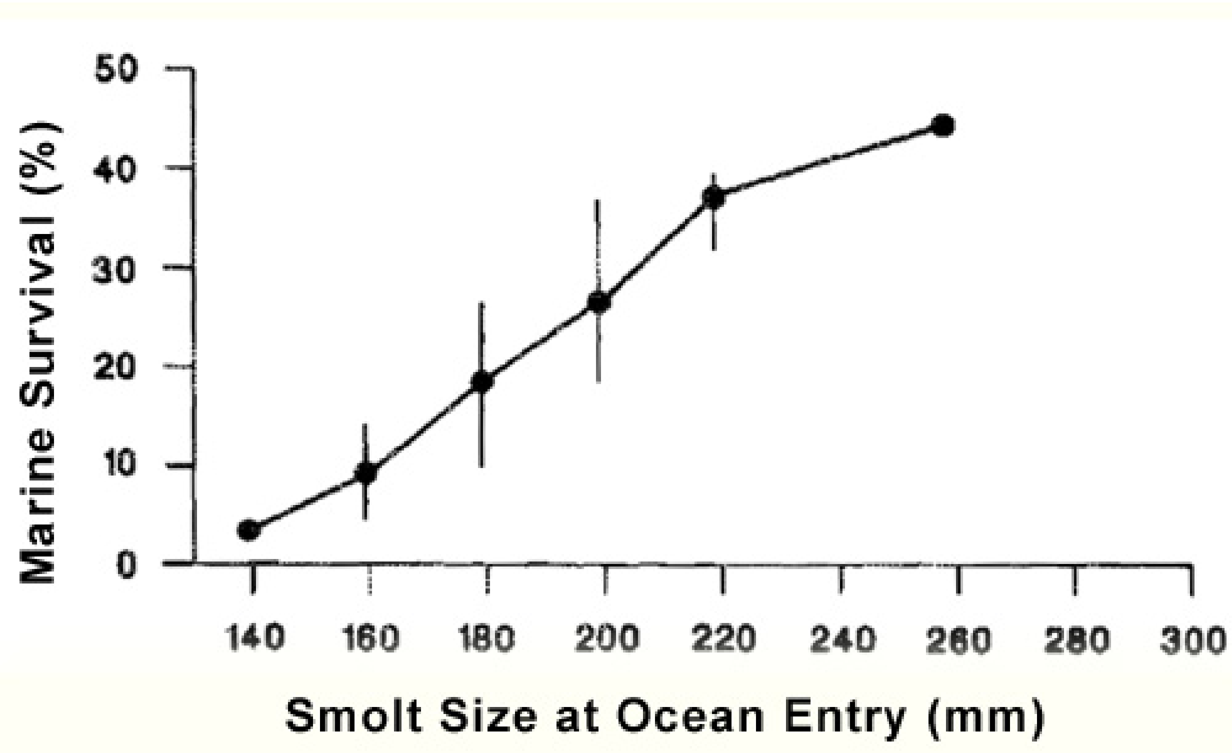


Figure 13-2. Marine survival of steelhead as a function of body size at ocean entry, in the Keogh River steelhead population described by Ward *et al*. (1989). Figure depicts the average survival to spawning of smolts emigrating in years 1977 - 1982.

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 was highly nutritious for the fish. Habitats with more frequent inputs of terrestrial insects would afford larger growth opportunities.

Additionally, 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 the wet season, because their seasonal low flows prevents the establishment of a large permanent population of resident rainbow trout.

Finally, this suggests recovery prospects for steelhead runs could be significantly improved by identifying, restoring, and protecting freshwater habitats that 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: 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 (including some small on-channel impoundments and/or areas with augmented summer flow) supporting 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 (Moore 1980, Smith and Li 1983, Smith 1982, Casagrande 2010). 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, in particular, to what extent are seasonal lagoons used as nursery areas and promote growth of juveniles prior to emigration to the ocean? 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 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 the region (due to the general similarity of climate, terrestrial watershed conditions, and the raised coast), there is also significant variation due to small differences watershed condition or coastal wind and current patterns *etc*. which can, translate into large differences in the suitability of lagoons as steelhead nursery habitat (Rich and Keller 2013, 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 estuaries currently capable of serving as reliable steelhead nursery habitat and estuaries which could be restored to support these habitats in the future. Such studies should focus on factors enabling rapid growth of juvenile steelhead, identification of limiting factors and restoration potential, 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 mainstems 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 and where artesian flows or other groundwater inputs kept water sufficiently cool in the summer (C. Swift, personal communication). Most mainstem (including riparian) habitats have now been highly altered by agricultural clearing high rates of sediment input, and groundwater pumping, so an effort to determine their potential to contribute to steelhead recovery would require a focused effort. However, lower mainstems with sandy substrates, such as the Pajaro and Salinas Rivers, with naturally low summer flows, and seasonally hydrologically disconnected from upstream spawning and rearing habitat, may have provided limited over-summer rearing opportunities prior to major watershed development (see Snyder 1913).

Recommendation: The potential nursery role of mainstem habitats is much more speculative than the nursery role of lagoons because mainstem habitats were degraded prior to most modern fishery assessments. 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, food availability 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 (*i.e.,* those in which some reaches only flow seasonally), 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 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 the potential size of the steelhead population.

Boughton *et al*. (2009) found 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 migratory 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 residual pools may benefit from enhanced growth. One mechanism for enhanced growth may be cannibalism of trapped cohorts. However, the high food demands and small portion that actually result in growth may require that most of the fish would be consumed. 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 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.

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 one or more robust anadromous populations be carefully characterized (*e.g.*, San Carpoforo and Arroyo de la Cruz Creeks in the San Luis Obispo Terrace BPG). The answer is more useful in the long-term, as an indicator of progress toward recovery, than it is in the short term. 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 potentially non-Core populations) to determine the numbers of spawners using both mainstem and tributary spawning habitats.

13.3.8 Clarify Population Structure

Discussion: Population structure is shaped by 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

[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.

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). These groups may in some cases be as small as those occurring in individual tributaries, or groups of tributaries within a single watershed (*e.g.*, Arroyo Seco within the Salinas River watershed, upstream tributaries with the Carmel River watershed).

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, exchanges within" means that the proper context of most management strategies is the independent population: a recovery 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 independent populations. [3]

The independent population is also the fundamental functional unit for steelhead viability in a biogeographic area. 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 in application of the criteria.

[3] Over the longer term, a permanent change in population dynamics *would* be expected to extend 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 or other causes of local extirpation.

An analysis of a simple quantitative model led Boughton *et al*. (2007b`) to conclude an annual adult abundance of 4,150 fish was 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 to these questions of exchange patterns has implications for the scope and scale of recovery efforts. The answers depend 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 life history crossovers and dispersal between watersheds, and the implications for viability criteria are addressed in the following three sections, 13.3.9 through 13.3.11.

13.3.9 Partial Migration and Life History Crossovers

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?

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 populations. For one natural and eight hatchery populations in California, Donohoe *et al.* (2008) found 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 bi-directional 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 where the two life history forms functionally coexist.

This continuum has significant implications for viability criteria. Are the populations in South-Central California fully integrated, or do they avoid interbreeding. Boughton *et al.* (2007b) made recommendations that embodied these two possibilities (actually two endpoints of a continuum). In one scenario, criteria should be specified that would secure the ocean-going fish if they turn out to comprise a demographically independent population. Under the other scenario, criteria should be specified that secure the ocean-going fish if they depend on the resident form.

Answering the first question will take an extended research effort because it necessarily involves multiple populations studied over a number of years. Currently, staff from NOAA's SWFSC and 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. Their hypothesis 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 Hayes, *et al*. 2012, 2011, Satterthwaite *et al.* 2012, 2010, 2009).

Though this research is important progress on the anadromy/residency life history crossover phenomenon, it has limitations including a hypothetical framework subject to substantial uncertainties due to the use of a surrogate species from the Atlantic Ocean, and possible genetic constraints. At this time life history crossovers in *O. mykiss* have not been induced by manipulating size, growth rates or any other environmental factor. Also, the existence of a plastic life history strategy does not preclude the possibility of important genetic constraints. Even if the current model is broadly correct, the specific timing of sensitive periods, and the thresholds for the size and growth cues, could vary markedly among populations of steelhead due to genetic differences. The responses to environmental cues would therefore likely have a heritable component, and exhibit local adaptation to specific conditions.

Recommendation: Research on the mechanisms of life history plasticity in *O. mykiss* should be vigorously pursued. A successful recovery effort is unlikely without a better understanding of the functional relationship between resident and anadromous fish. Genetic markers might prove useful for distinguishing resident and anadromous fish in juvenile samples. Current research efforts should yield useful information over time, but these efforts focus on systems outside the SCCCS Recovery Planning Area: Soquel Creek in Santa Cruz County (a coastal redwood forest system near the northern boundary of the SCCC DPS), and the American River near Sacramento, California (a large Central Valley River system). Due to local adaptation of steelhead populations in South-Central California, some of the conclusions from these ongoing studies may not be directly applicable, particularly for the interior populations.

Because of the likelihood of local adaptation, it would be useful to address some related questions about the frequency of life history crossovers and their implications for recovery planning in the SCCCS Recovery Planning Area. 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 inform this goal. The principal uncertainty is how much the abundance of anadromous fish needs to be increased, a separate question depending 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 the 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 potential 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. Results from these studies should 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%. 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 identifying watersheds with stable conditions to 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 SCCCS 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 sustaining 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 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 could be revised downward (but also possibly upward in some cases) 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 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 top 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 meeting 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 are essential for assessing the attainment of recovery goals.

13.4.1 Strategy for Monitoring Steelhead in South-Central California Coast

SCCCS DPS 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 SCCCS DPS. The basic components of the SCCC steelhead monitoring strategy include:

- ❑ Reconnaissance surveys and assessments of steelhead populations;
- ❑ Reconnaissance surveys and assessments of riverine and estuarine habitat conditions;
- ❑ Monitoring stations stratified at both the BPG and population levels, and
- ❑ 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 CDFW 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 includes an, initial assessment both of the *O. mykiss* 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. Watershed and assessments and habitat inventory methods should be conducted using the protocol in the California Department of Fish and Wildlife's California Salmonid Stream Habitat Restoration Manual (Flosi *et al*. 2010).

Monitoring (or lifecycle) 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. Monitoring stations should initially be located in Core 1 populations in each BPG. However, since no trap system will work at 100% efficiency with the flashy winter flows characteristics of coastal watersheds, a mark-recapture system would be needed to determine actual numbers and to correct for trapping inefficiency.

Life cycle monitoring stations (LCS) can be co-located with monitoring 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 *O. mykiss* habitat use and habitat condition over time.

These efforts 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); and
- 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)

LCSs could also be used to evaluate 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 13-1 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 Locations of 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 Southern Pacific Trestle Fish Ladder(Uvas/Carnadero) Bloomfield Road Redwood Retreat Road City of Watsonville Fish ladder
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 Camp Pico Blanco Summer Dam
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 these and 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.

13.4.2 Monitoring Protocols

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 involve two components:

1. Observed counts for O. *mykiss* that contains information about adult run size; and

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, or proxies of presence (redd counts), can under- or over-estimate true number of *O. mykiss* depending on observer detection rates. For example, a large population where conditions are unsuitable for visually observations (*i.e.*, highly turbid waters during the winter period) may have detection rates similar to a naturally smaller population in a more pristine watershed with excellent observing conditions. Due to this and other inherent limitations, it is necessary to develop appropriate confidence intervals for population estimates which are based on appropriate and flexible sampling techniques.
Williams *et al*. (2001) provides a comprehensive technical review of applicable protocols which require repeated observations (often only two times) of the same group of fish (see also Rosenberger and Dunham 2005).

13.4.2.1 Counting at Fish Ladders

Fish ladders can provide important opportunities to count upstream migrants, because they can facilitate better estimates of a population when the majority of a run must migrate through the ladder[4] Nonetheless, estimates of abundance at ladders can pose technical challenges for fish detection and counting devises because of the extremely flashy systems characteristic of South-Central California (see discussion below). Counts at ladders, while potentially more accurate than estimates derived from other methods, are only relevant to areas where these structures exist and cannot be used to 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. They estimated Chinook salmon, coho salmon and steelhead escapement in several coastal streams in northern California through a stratified index redd method. Escapement estimates were compared with 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-

[4] Assuming the fish passage facilities themselves provide effective and relatively unimpeded fish passage opportunities.

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 survey reaches are 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 or ladder to make counts, but has other advantages:

1. There is no need for a weir or other device that impedes flow. The absence of a hardened structure eliminates concerns regarding fouling, destruction by high-flow events, etc.; and

2. A DIDSON device can detect fish in turbid waters (unlike a regular video camera).

These traits make a DIDSON acoustic camera a tool that is well suited for evaluation of steelhead runs in the flashy, turbid conditions typical of most 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 of a DIDSON are:

1. The cost of the device;

2. Deployment constraints for obtaining good images; and

3. The risk of "flashy flows" damaging or destroying the device.

This tool has the potential to solve some of the difficult problems of monitoring steelhead in South-Central California, particularly 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.

The monitoring phase uses 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 potential for monitoring runs of steelhead when many other methods are problematic. In unpublished simulations, Boughton found 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 issues that should be considered in using implanted tags include:

- mortality/fitness risks;
- permitting requirements;
- total tagging effort necessary to achieve acceptable levels of statistical significance

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 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, would have greater statistical power for determining if recovery actions on the freshwater side are actually having the desired effect.

NMFS Staff scientist 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, a fraction of juveniles are collected for otoliths and to evaluate genetic relatedness. From these data, the number of anadromous mothers (and as a byproduct, non-anadromous mothers) for each annual cohort of young-of-the year fish could be estimated. 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. Field work would consist of collecting juveniles at randomly-sampled stream reaches each summer. However, the method would require the time and expense of otolith analysis, and it would require 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. An unknown variable is the appropriate sample size to obtain 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 (Williams *et al.* 2009, Walters 1997, 1996). Adaptive management is predicated on the recognition that natural resource systems are variable, and knowledge of natural resource systems is often uncertain. Further, the response of habitats 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 recovery actions are couched in broad terms and will be given more specificity on a case-by-case basis as projects are proposed, developed, and subject to environmental and regulatory agency review for permitting purposes, and ultimately assessed for their effectiveness.

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 should contain three components: 1) adaptive experimentation by which scientists and others with appropriate expertise, learn about habitat response to recovery or management actions; 2) public education and 3) shared decisions making. 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 through an iterative process to help stakeholders maintain focus on objectives and develop appropriate revisions. The recovery goals, objectives, and criteria in Chapter 6, Steelhead Recovery Goals, Objectives & Criteria, should provide a basic framework. Additionally, recovery actions identified for each BPG should be a starting point for the adjustment of recovery actions. 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 were identified in the use of adaptive management program to test hypotheses regarding 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. 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 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 requires a design based upon scientific knowledge and principles. Practical questions 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 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 provisions for incorporating recovery goals and actions must be incorporated into all of the programs and actions which NMFS administer and implement. This includes, for example, listing status 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 Strategic Plan (National Marine Fisheries Service 2006a). The Interim Recovery Planning Guidance (National Marine Fisheries Service 2010b) also outlines how NMFS shall cooperate with other agencies regarding plan implementation. These documents, in addition to the ESA, will be used by NMFS to establish the framework for Recovery Plan implementation. The 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 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" (NMFS 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 to directly inform recovery objectives and goals;

- Participating in the land use and water planning process at the federal, state, and local level to ensure 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 Listing Status Reviews of each listed species.

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 considerable, 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 stakeholders implementing the plan or contemplating actions that may impact the species' chances of recovery.

NMFS is engaged in outreach to various constituencies where NMFS 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 focus on those stakeholders with which we already engage and to expanded sets of stakeholders, including, but not limited to, 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 Recovery Planning Area;

- 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; and

- Work with California Regional Water Quality Control Boards to promulgate methods to detect and manage impacts from pesticides and other contaminants of special 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 SCCCS DPS 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 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 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, 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 effectuate 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 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 in NMFS's West Coast Region. Of necessity, some of these methods address the urgent issues of staffing and workload that NMFS faces. As a result, NMFS's commitment to implementing Recovery Plans extends to the way the many requests for consultations and permits are prioritized.

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 for SCCCS DPS 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 designations. 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 encourage acquisition of 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 adversely 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 "ensure 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 adverse 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 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 land and water use practices on private ownership do not trigger interagency consultation (with notable exceptions involving the waters of the United States that traverse private land holdings).

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;
- Develop section 7 Conservation Recommendations to help prioritize Federal funding towards recovery actions (NFMS, USFWS, NRCS, EPA, *etc.*) during formal consultations;
- Encourage Federal agencies to ensure biological assessments comport to 50 CFR 402.14(c) prior to initiating consultations with NMFS; Compliance with these requirements is expected to increase consultation effectiveness and timeliness;
- Encourage all Federal agencies, or their designated representatives, to conduct field reviews 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 reviews to NMFS; and,
- Encourage Federal agencies to coordinate and develop programmatic incidental take authorization for activities that contribute to the recovery of SCCCS DPS to streamline their permitting processes

14.2.4 ESA Section 9

Section 9 prohibits any person from harming individuals 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 West Coast Region 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 NMFS's West Coast Region and Enforcement to ensure activities by NMFS staff, when supporting NMFS' OLE are focused on the highest recovery priorities; and
- When take has occurred, NMFS West Coast 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 an extended period to implement and until recently 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 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 variant gene (allele) among the chromosomes carried by individuals in 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.

Artificial Propagation
Anthropogenic assistance in the reproduction of an organism. With Pacific salmonids this may include spawning and rearing in hatcheries, transfer of stocks from one system to another, creation or modification of spawning habitat, egg bank programs, captive broodstock programs, and cryopreservation of gametes.

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 plants.

Autotrophic
Making food by photosynthesis or requiring only inorganic chemicals 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; they 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 (n).

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, 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 higher 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.

Captive Broodstock Program
A form of artificial propagation involving the collection of individuals or gametes from a natural, wild population and rearing the individuals to maturity in captivity.

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 supporting 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 is adversely impacted.

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 steep 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, or other defined taxonomic group.

Continental Shelf
The underwater shelf of the continent, extending seaward from the shore, with a moderate declination, to the edge of the continental slope where the declination 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
The character of a population whose condition is determined by 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; maintaining an equable climate, control of diseases, pests, and sediment supplies (*e.g*., to coastal beaches); supporting services such as soil formation, photosynthesis, nutrient cycling; 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 used in many models in population genetics to express information about expected rates of random genetic change due to inbreeding and/or genetic drift.

El Niño /La Niña Southern Oscillation (ENSO)
A weather pattern that occurs across the tropical Pacific Ocean roughly every five to seven years. It is characterized by variations in the sea-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 an area. 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 the phenotypic expression of genes.

Epigenome
All the epigenetic modifications of 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 terrestrially derived sediments). The inflow of both seawater and freshwater provide high levels of nutrients in both the water column and saturated 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 flow 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 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 a river to the 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.

Imprinting
The physiological and behavioral process by which migratory fish acquire the ability to recognize environmental cues that 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, or intersect high groundwater tables.

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 once during its life. Steelhead are the only members of the Pacific anadromous salmonids (*Oncorhynchus* spp.) that do not necessarily die after initial spawning , and may emigrate back to the ocean and then return to freshwater to repeat their reproductive phase.

K-Strategist
A species characterized by a relatively later age at first reproduction, small brood size, few progeny, extensive parental care, and long juvenile periods. Populations exhibit exponential growth rate followed by stable population size, and tend to live in stable environments. Mammals and trees are examples of k-strategist species (see **R-Strategist**).

Kelt
A spawned out anadromous fish; it is generally emaciated and weak as a result of its spawning activity and lack of nourishment.

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 as 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 an organism's growth or a 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 a 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, and fin-ray counts, *etc*.

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 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 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; they include 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 specific 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 moving air masses 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 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; however, the embryos receive 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 on mating (*e.g.*, genetic or behavioral).

Parameterization
A technique used in constructing models by substituting an unknown feature such as a process or a 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 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 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.

Rainbow Trout
The resident freshwater form of *Oncorhynchus mykiss.* Individuals can interbreed with the anadromous form of *O. mykiss*, but may or may not be the progeny of the anadromous form, and may or may not produce progeny that exhibit an anadromous life cycle (see Steelhead).

R-Strategist
Species characterized by relatively early age of first reproduction, large brood size, numerous progeny, little 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 (See **K-Strategist**).

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 layers (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).

Self-sustaining Population
A population that perpetuates itself without human intervention, and without chronic decline, in its natural ecosystem, at sufficient levels that listing as threatened or endangered under the ESA is not warranted.

Semelparous
Organisms which reproduce only once. The single reproductive event of semelparous organisms is usually copious, as well as fatal to the reproducing organism. An example of a semelparous organism are the various species of 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 a 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
The anadromous form of *Oncorhynchus mykiss*. Individuals can interbreed with the non-anadromous form of *O. mykiss* (Rainbow trout), but may or may not be the progeny of the anadromous form, and may or may not produce progeny that exhibit an anadromous life cycle (see **Rainbow Trout**).

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. In statistics, the classification of data into categories or subcategories on the basis of selected criteria.

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, rather than the more typical two; triploid individuals are generally infertile, or incapable of reproduction.

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, 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 near the coast 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: 1) abundance, 2) growth rate, 3) spatial structure, and 4) diversity (including genetic and phenotypic diversity).

Volitional Fish Passage
The movement of fish at natural rates of migration in response to cues such as natural flow patterns or water temperature, or other 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 early 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 (United States)
ACWA	Association of California Water Agencies
AG	Arroyo Grande
ASRA	Arroyo Seco River Alliance
BCLC	Big Creek Lumber Company
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
CDFW	California Department of Fish and Wildlife
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
CSWRCB	California State Water Resources Control Board
CT	California Trout
CCSD	Cambria Community Services 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

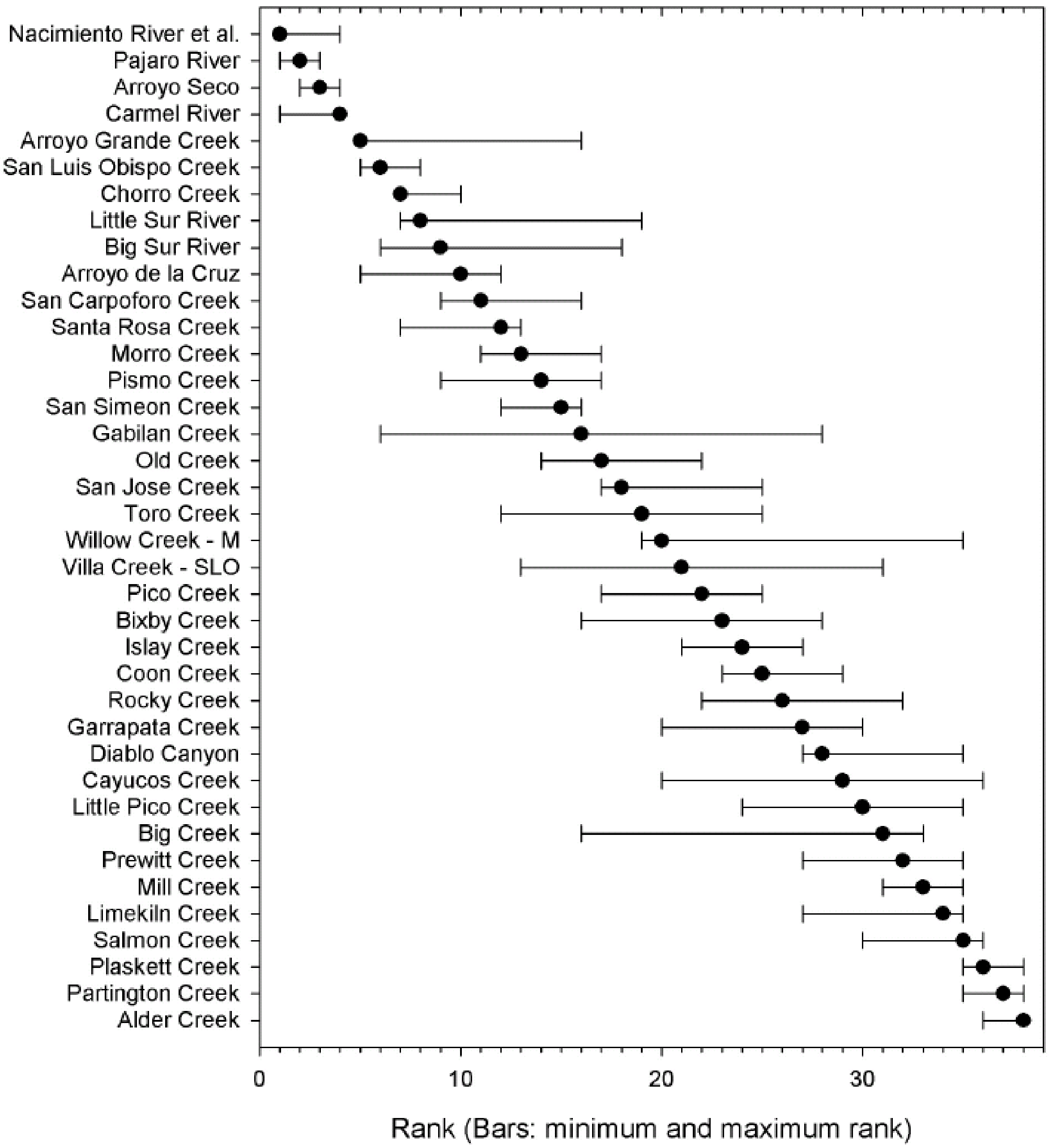
CI	Confidence Interval
CMARP	Comprehensive Monitoring Assessment and Research Program
C^0	Centigrade
cm	Centimeters
cm/sec	Centimeters per second
COA	City of Atascadero
COC	City of Carmel
COM	City of Monterey
COMB	City of Morro Bay
COG	City of Gilroy
COPS	City of Paso Robles
COPB	City of Pismo Beach
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 Niño/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
MC	Monterey County
MCWD	Marina Coast Water District
MOU	Memorandum of Understanding

MNNEP	Morro Bay National Estuary Program
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 (Unites States)
NOAA	National Oceanic and Atmospheric Administration (United States)
NPSPWRO	National Park Service, Pacific Western Regional Office (United States)
NRCS	National Resources Conservation Service (United States)
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 Analysis
RFID	Radio Frequency Identification
RM	River Mile
RST	Rotary Screw Trap
RWQCB	Regional Water Quality Control Board (State of California)
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
SLOCFB	San Luis Obispo County Farm Bureau
SCC	Santa Clara County
SCCRCD	Santa Cruz County Resource Conservation District
SCRC	Santa Cruz County
SCVWD	Santa Clara Valley Water District
SLP	Santa Lucia Preserve
SLOC	Santa Luis Obispo County
SVFFC	Salinas Valley Fly Fishers Club
SWP	State Water Project
SWRCB	State Water Resources Control Board (State of California)
TBSLT	The Big Sur Land Trust
TCLT	The Cambria Land Trust
TLCSLOC	The Land Conservancy of San Luis Obispo County
TBD	To Be Determined
TNC	The Nature Conservancy
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, Camp Roberts)
WCB	Wildlife Conservation Board (State of California)

APPENDIX B
Watershed Intrinsic Potential Rankings

Watershed rankings in the South-Central California Coast Steelhead DPS. These rankings are based on the amount of potential habitat (in an unimpaired state) 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).



APPENDIX C

COMPOSITION OF SOUTH-CENTRAL CALIFORNIA COAST STEELHEAD RECOVERY PLANNING AREA BPGs

Watersheds identified within each of the four Biogeographic Populations Groups in the South-Central California Coast Steelhead DPS are essential components of a recovered 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) METHOD

Introduction

NMFS assessed current and emerging threats to the persistence and recovery of steelhead populations of the SCCCS Recovery Planning Area. This assessment focused on a set of watersheds identified by the TRT and NMFS staff and used the Nature Conservancy's Conservation Action Planning (CAP) method (The Nature Conservancy 2005). 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 CAP threats assessment is iterative and can be updated as new information becomes available or during periodic status reviews of the species (Kier Associates and National Marine Fisheries Service 2008a, 2008b, Hunt & Associates 2008a, 2008b). CAP workbooks have been developed previously for salmonid threat assessment and recovery planning for southern Oregon and northern California coast coho.

The Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) contracted with Kier Associates and Hunt & Associates Biological Consulting Services to provide technical support in developing Recovery Plans for *Oncorhynchus mykiss* populations in the South-Central/Southern California Coast Steelhead Recovery Planning Area. Kier Associates was tasked with developing GIS-based data on watershed conditions, and a set of reference values drawn from the existing scientific literature; however, because of lack of available local regional studies several of these reference values were based on studies of more northern populations of steelhead that may have different habitat requirements or tolerances, and so may not in all cases represent the environmental conditions in which more southern populations have evolved (*e.g.*, water temperature, estuarine conditions, seasonal drying of freshwater mainstem or tributary habitats). 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 on a watershed/landscape scale, and identifying a comprehensive suite of recovery actions across the South-Central California Recovery Planning Area (Hunt & Associates 2008a, 2008b). These documents summarize the method used to assess *O. mykiss* threats and sources of threats to southern steelhead populations, including those in South-Central California coastal watersheds from the Pajaro River at the border between Santa Cruz and Monterey Counties south to, but not including the Santa Maria River, at the border between San Luis Obispo and Santa Barbara Counties. The CAP workbook threat source rankings presented in this recovery plan also incorporate additional information derived from a wide variety of investigations, studies, and watershed plans developed since the initial preparation of the CAP Workbooks in 2008.

Method

The CAP method results in a series of workbooks for individual watersheds, or sub-watersheds. The Workbooks are an Excel database tool developed by The Nature Conservancy as a strategy for evaluating and prioritizing conservation, restoration, and land management planning efforts. NMFS adapted the CAP Workbook for use in the threat assessment portion of the steelhead recovery planning process (using the reference values developed by Kier Associates 2008a). The Workbook provided a tiered analytical framework for documenting existing conditions and identifying prioritizing the types of recovery actions to address systemic threats in individual watersheds; they are not, however, intended to be a substitute for the design of site-specific recovery actions. A Workbook was developed for each of the 27 selected watersheds (or sub-watersheds) in the SCCCS Recovery Domain identified has having high intrinsic potential, that is, the potential to support an independent viable population in an unimpaired condition (Boughton *et al.* 2006). Several small watersheds were added to the initial suite of watersheds considered in the recovery planning, based on input from NMFS staff. Conservation targets, in this case life history stages such as egg, fry juvenile, smolt, and adult, provided the first tier of analysis. Key ecological attributes of each life history stage, such as water quality, spawning habitat quality, migratory corridor status, *etc*. were identified at the second tier of analysis. These attributes are aspects of steelhead ecology or the environment that, if lost or significantly degraded, could lead to loss of that life history stage. The third tier was ecological indicators (parameters) that measure the status of each key ecological attribute for a particular life history stage, *e.g.*, average percentage of fine particles in substrate for adult spawning and egg development stages. Provisional boundary conditions for each indicator delineated suitable versus unsuitable habitat conditions for the various life history stages.

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 NMFS and CDFW staffs, as well as stakeholders and other interested parties at a series of public workshops held in 2007. Additionally, since the completion of the formal CAP Workbook assessment in 2008, NMFS reviewed and evaluated a wide variety of investigations, studies, and watershed plans developed or located subsequently.

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 method 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 further developed, tracked, and up-dated, based on changing current conditions.

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; this conservation target has been the most useful for the SCCCS Recovery

Planning Area because of the lack of established reference values and site (reach) specific information on individual 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). See comment above regarding "Multiple Life Stages".

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 (2008a). 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.

Given the large areal extent and complexity of conditions within the SCCCS Recovery Planning Area, the method uses indicators of habitat at local, regional, and landscape-scales. For example, land use indicators such as density of roads per square mile of watershed have been widely employed as a landscape-scale metric of watershed "health" for salmonids throughout the western United States (see Kier Associates and NMFS, 2008b). Landscape-scale indicators were used in this threat assessment to overcome logistical and analytical problems inherent in local-scale indicators of *O. mykiss* habitat quality (*e.g.*, water temperature), that exhibit extreme spatial and temporal variation, which can lead to misinterpretations. While local-scale indicators tend to exhibit extreme spatial and temporal variation they may be critical in planning and designing site-specific recovery actions.

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 watersheds 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, though this type of information may be more useful in designing site specific recovery actions than for recovery planning at a landscape-scale.

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, delayed migration, *etc.*). Within the CAP Workbook threats (source of stress) are ranked as "Very High," "High," "Medium," or "Low" and inputs the rank into the next step of the assessment. In theory, this process is repeated for each conservation target (egg, fry, juvenile, smolt, and adult), where such data exists, as well as for 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, etc.), 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 third 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 method is the ability to update the assessment as information becomes available. In the interim, professional judgment – supplemented by more recent investigations - must be used to address such gaps until such time as field derived, quantitative data are available.

The set of watersheds assessed with the CAP Workbook method in the SCCCS DPS are identified in Table D-1, and arranged geographically (north to south) within each of the 4 BPG

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

NMFS used two sets of CAP Workbooks prepared independently by two consultants (Kier Associates and Hunt & Associates), but using a common set of reference values, for its threat assessments and related recovery actions. As noted above, Kier Associates developed the reference values and analyzed a set of watersheds using a set of available GIS-based landscape indicators (*e.g.*, number of miles of roads per square mile of watershed, extent of agricultural conversion of watershed, riparian canopy cover, *etc.*) and a small number of point-data measurements of key ecological attributes (*e.g.*, dissolved oxygen, water temperature, *etc.*) believed to be important for assessing habitat conditions for steelhead (Kier Associates and NMFS 2008a, 2008b). The CAP Workbooks prepared by Hunt & Associates used the reference values developed by Kier Associates, but added ground-based information on existing *O. mykiss* conditions in each selected watershed from a broad range of published and unpublished materials, including: peer-reviewed scientific publications; technical reports, federal, state, and local planning documents; EIR/EISs, management plants; passage barrier assessments; project-driven habitat evaluations; field surveys; information provided by NMFS and CDFWS staffs; and stakeholder input gathered at a series of public workshops held in 2007 (Hunt & Associates Biological Consulting Services 2008a).

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 covered by impervious surfaces, has strong predictive power of general habitat conditions for steelhead because paved surfaces have manifold adverse effects on habitat quality, water quality, and the hydrology of streams.

Hunt & Associates developed CAP Workbooks for 27 drainages across the South-Central California Steelhead DPS (Hunt & Associates 2008a). Kier Associates CAP Workbooks for 23 drainages across the South-Central California Steelhead DPS (Kier Associates and National Marine Fisheries Service 2008b).

Table D-2 compares the results of the two independent threats assessments 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 not always represent important differences in overall habitat quality. Table D-2 explains discrepancies between "Poor-Fair" and "Good-Very Good" categories between the Hunt & Associates and Kier Associates CAP Workbook assessments.

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 threats 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 and CDFWS staff familiar with the selected watersheds to override certain assessments generated through the formal CAP Workbook process, and additional information developed or located in subsequent development phases of the SCCCS Recovery Plan. Finally, in addition to the CAP threats assessment, NMFS considered how predicted changes in climate and the marine environment may affect the species ability to recover and persist.

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

Key: dark green = very good conditions; light green = good conditions; yellow = fair conditions; red = poor conditions.

** Watersheds analyzed only by Hunt & Associates are not shown. 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)..*

*** Pervasive discrepancies between Hunt Associates vs. Kier Associates "poor" and "fair" categories here are due to fewer indicators used in the latter analyses.*

The full CAP Workbooks, with references, are available on CDs upon request to NOAA's Long Beach, CA.

APPENDIX E

RECOVERY ACTION COST ESTIMATES FOR STEELHEAD RECOVERY PLANNING

Introduction Cost

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 SCCCS Recovery Plan identifies categories of systemic threat sources within individual watersheds across the SCCCS Recovery Planning Area 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 habitats). 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 SCCCS 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 strategy and actions.

The recovery action tables (Tables 9-4 through 12-10) developed for each BPG within the SCCCS Recovery Planning Area 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 the costs of individual types of recovery actions were estimated.

NMFS's has utilized a series of assumption tables for costs derived initially from the NMFS'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 SCCCS Recovery Planning Area.

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 cost estimates 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 14, 15 and 19).

Dams and Diversions

The cost estimates to implement 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 (see Assumptions and Categories Tables 4, 5 and 9).

Other Passage Barriers

Culvert replacement cost estimates 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 Tables 7 and 10).

Groundwater Management

Groundwater management cost estimates were 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 cost estimates for levee and channelization-related recovery actions were made using a GIS data base to perform a dimensional analysis of parameters such as stream length, acreage, *etc*. Based on these results, costs were assigned on a per mile or per acre basis. As with large dams and diversion, while this method may be useful for managing existing facilities, the modification or 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, 11, 12, 13 and 15).

Mining and Quarrying

The cost estimates for aggregate mining operations were 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, 2 and 13).

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 cost estimates for controlling and removing non-native species were derived on a per acre basis and a staff time scenario. The education and outreach costs were 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 1, 2, 17 and 18).

Urban Development

The cost estimates for recovery actions focused on urban development threat sources were 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 Tables 1, 2 and 8).

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 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 cost estimates 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, 16 and 19).

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 inadequate regulatory mechanisms action where additional FTEs accounted for
[2] See U.S. Bureau of Labor Statistics, FTE assumption table (2009) 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: U.S. 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: Rhode Island Department of Environmental Management, 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: Thompson and Pinkerton 2008 (pp. 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: Thompson and Pinkerton 2008 (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

1

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

1

Source: Thompson and Pinkerton (pp. 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: Thompson and Pinkerton (pp. 43-44)
[2] Source: California Department of Transportation 2010

Table 9. New Fish Ladder[1]	
Waterway Size	**Cost ($)**
Large	1,022,727
Small	568,181

[1] Source: Thompson and Pinkerton 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: Thompson and Pinkerton (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: California Department of Fish and Wildlife 2004b (pp. 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: Thompson and Pinkerton (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: Thompson and Pinkerton 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: Thompson and Pinkerton 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: California Department of Fish and Wildlife 2004b (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. Fish and Wildlife Service 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: Thompson and Pinkerton 2008 (pp. 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	242,786,265	Pajaro River Salinas River	96,590,000	No Core 2 populations Identified	N/A
Carmel River Basin	114,860,165	Carmel River	114,860,165	No Core 2 populations Identified	N/A
Big Sur Coast	18,030,165	San Jose Creek Little Sur River Big Sur River	10,029,885	Garrapata Creek Bixby Creek Willow Creek Salmon Creek	8,000,280
San Luis Obispo Terrace	197,982,390	San Simeon Creek Santa Rosa Creek Pismo Creek San Luis Obispo Creek Arroyo Grande Creek	80,654,985	San Carpoforo Arroyo de la Cruz Little Pico Creek Pico Creek Morro Creek Morro Bay Estuary (Chorro Creek, Los Osos Creek)	117,327,405

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 Wildlife 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
- County Fish and Wildlife Advisory Commissions (Santa Cruz, Santa Clara, San Benito, Monterey, San Luis Obispo Counties)

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 Wildlife, 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; for mosquito control best management practices, see California Department of Public Health and Mosquito and Vector Control Association of California 2010:

- 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 are 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, or 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 active pesticide 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.), Cape ivy (*Delairea odorata),* 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. *
- Consult and coordinate with licensed Pest Control Advisors in the development of Integrated Pest Management Plans that include multiple strategies addressing cultural, mechanical, biological, and chemical controls.

*For a periodically up-dated list of invasive plants identified by the California Invasive Plant Council see: www.cal-ipc.org.

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