SOUTHERN CALIFORNIA STEELHEAD RECOVERY PLAN

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Southwest Regional Office
National Marine Fisheries Service
Long Beach, CA

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EXECUTIVE SUMMARY

Status of Southern California Coast Steelhead

Steelhead is the anadromous form of the species *Oncorhynchus mykiss*. The term "anadromous" refers to the species' life-history strategy of migrating to the ocean as juvenile and sub-adult fish and then returning to spawn in the freshwater stream where they were born after several years of growth in the ocean. Steelhead populations along the west coast of the United States have experienced substantial declines in abundance as a result of human activities such as water development, flood control programs, forestry practices, agricultural activities, mining, and urbanization that have degraded, simplified, and fragmented aquatic habitats. In southern California, at the southern limit of the range for anadromous *O. mykiss* in North America, it is estimated that annual runs have declined dramatically from 32,000-46,000 returning adults historically, to less than 500 returning adults today (Good *et al.,* 2005).

Steelhead in southern California comprise a "distinct population segment" (DPS) of the species *O. mykiss* that is ecologically and reproductively discrete from the remainder of the species along the West Coast. Therefore, under the under Federal Endangered Species Act of 1973 (ESA), this DPS qualifies for protection as an individual species. In 1997, the Southern California Steelhead DPS was first listed as an "endangered" species, or a species that is in danger of extinction throughout all or a significant portion of its range.

Recovery Planning

The ESA mandates that the National Oceanic and Atmospheric Administration (NOAA), 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 Southern California Steelhead DPS is considered vital to the continued persistence and recovery of anadromous *O. mykiss* in this region.

The Southern California Steelhead DPS encompasses *O. mykiss* populations in watersheds from the Santa Maria River (just north of Point Conception) south to the Tijuana River at the U.S.-Mexico border. For recovery planning purposes, this area is known as the Southern California Steelhead (SCS) Recovery Planning Area. It includes those portions of coastal watersheds that are at least seasonally accessible to anadromous *O. mykiss* entering from the ocean or that would be accessible in the absence of man-made passage barriers.

Recovery Plans developed under the ESA are guidance documents, not 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 implementing other provisions of the ESA with respect to a particular species, including 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 criteria and goals by describing the criteria by which NMFS would measure species recovery, the strategy to achieve recovery, and the recovery actions necessary to achieve viable populations of steelhead within the SCS Recovery Planning Area.

Environmental Setting

The topography of the SCS Recovery Planning Area is dominated by a series of steep mountain ranges, coastal valleys, and coastal terraces. Watersheds within the region fall into two basic categories: those characterized by short coastal streams draining mountain ranges immediately adjacent to the coast (*e.g.*, Santa Ynez, Santa Monica, Santa Ana mountains), and those watersheds containing larger river systems that extend inland through gaps in the coastal ranges (*e.g.*, Santa Maria, Santa Ynez, Ventura, Santa Clara, San Gabriel, Santa Ana, and San Diego Rivers).

The climate in the SCS Recovery Planning Area is Mediterranean, with long dry summers and brief winters with short, sometimes intense cyclonic winter storms. Rainfall is restricted almost exclusively to the winter months (December through March), though the extreme southern portion of the SCS Recovery Planning Area is subject to occasional summer storms originating from the Gulf of California. Snow accumulation is generally small and of short duration, and does not contribute significantly to peak run-off in this region. The California floristic province 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 between years. Additionally, there is a wide disparity between winter rainfall from north to south, as well as between coastal plains and inland mountainous areas.

Base flows (average dry-season flows) in these rivers are determined by groundwater inputs, which are 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 river reaches with perennial and seasonal surface flow) controlled by geologic formations, and the strongly seasonal precipitation pattern characteristic of a Mediterranean climate. Water temperatures are generally highest during summer months, but can be locally cooled by springs, seeps, and rising groundwater, creating refugia where conditions remain suitable for salmonids, even during the summer.

Significant portions of the upper watersheds within the SCS Recovery Planning Area are contained within four national forests (Los Padres, Angeles, San Bernardino, and Cleveland National Forests). These forests are managed primarily for water production and recreation (with limited grazing and oil, gas, and mineral production).

Urban development is concentrated in coastal areas and inland valleys, with the most expansive and densest urban development located within the Los Angeles Basin. The Recovery Planning Area is home to more than 20 million people, over half the population of the State of California. Some coastal valleys, and foothills, are extensively developed with agriculture, principally row-crops, citrus and fruit trees, and vineyards.

Recovery Goals and Viability Criteria

The overarching goal of this Recovery Plan is the recovery of the Southern California Steelhead 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 which, when met, would result in a determination in accordance with the provisions of the ESA that the species be delisted (50 CFS 17.11 and 17.12).

Recovery criteria are built upon criteria recommended by the NMFS Technical Recovery Team (TRT) for the identification of viable anadromous *O. mykiss* populations and DPS. 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 sufficiently dispersed spatially, but well connected 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 and its natural environments necessary for both individual populations and the DPS as a whole to be viable, *i.e.,* persist over a specific period of time, regardless of other ongoing anthropogenic effects.

Recovery of the endangered Southern California Steelhead DPS will require recovery of a sufficient number of viable populations within each of five Biogeographic Population Groups (BPGs) defined by the TRT. 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 DPS as a whole. Each population, which may be contained within a single watershed or may be a group of interacting fish between adjacent or nearby watersheds, must exhibit a set of biological characteristics (*e.g.,* minimum mean annual run size, persistence over long-term oceanic conditions and variation, spawner density, anadromous fraction, *etc*.) in order to be considered viable. Additionally, the DPS as a whole must contain a minimal number of viable populations, or interacting trans-basin populations, within each BPG that inhabit watersheds with drought refugia (needed to sustain juvenile populations throughout the low-flow period), are geographically separated (to maintain maximum genetic diversity and also to spread out the risk of extinction due to local disasters or other mortality factors), and exhibit the natural life-history diversity of the species (fluvial-anadromous, lagoon-anadromous, and freshwater resident).

Achieving species recovery will require a number of coordinated activities, including: implementation of the strategic and threat-specific recovery actions identified in this Recovery Plan; monitoring of existing population's response to recovery actions; and further research into the diverse life-history patterns and adaptations of southern anadromous *O. mykiss* to a semi-arid and highly dynamic environment (*e.g.,* the ecological relationship between anadromous and non-anadromous life-history patterns).

Effective implementation of recovery actions will also entail: (1) extensive public education (including the general public, non-governmental agencies, and local, regional, State, and Federal governmental agencies,) regarding the role and value of the species within the larger watershed environment; (2) development of cooperative relationships with private land owners, special

districts, and local governments with direct control and responsibilities over non-federal land-use practices; (3) participation in the land use and water planning and regulatory processes of local, regional, State, and Federal agencies; (4) close cooperation with other state resource agencies such as the California Department of Fish and Game, California Coastal Commission, CalTrans, and the California Department of Parks and Recreation; 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, and the U.S. Environmental Protection Agency.

Recovery Strategy

A comprehensive strategic framework is necessary to serve as a guide to integrate the actions contributing to the larger goal of recovery of the Southern California Steelhead 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 specific BPGs.

NMFS has identified core populations intended to serve as the foundation for the recovery of the species in the Recovery Planning Area. In addition, threats assessments for the species indicate that recovery actions related to the modification of existing passage barriers and changes in water storage and management regimes within certain rivers of the Recovery Planning Area are critical to the recovery of the species. High quality habitat exists above the significant passage barriers in these river systems. As a result, NMFS expects significant improvements in species status once they are able to access these areas for spawning and rearing of young steelhead.

There remain uncertainties regarding the level of recovery necessary to achieve population viability, therefore, additional research and monitoring of anadromous *O. mykiss* populations within the SCS Recovery Planning Area is an essential component of this Recovery Plan. As this Recovery Plan is implemented over time, additional information will become available to: 1) refine the viability criteria; 2) up-date and refine the threats assessment and related recovery actions; 3) determine whether individual threats have been abated; and 4) evaluate the overall viability of anadromous *O. mykiss* in the SCS Recovery Planning Area. Additionally, there will be a review of the recovery actions implemented and population and habitat responses to these actions at the 5-year and 10-year status reviews of the DPS.

Recovery Actions

Many complex and inter-related biological, economic, social, and technological issues must be addressed in order to recover anadromous *O. mykiss* in the Southern California Steelhead 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 throughout southern California, flow conditions for anadromous salmonids will limit recovery. Similarly, recovery is unlikely without programs to restore properly functioning historic habitat such as estuaries, and access to upstream spawning and rearing habitat. Many of the recovery actions identified in this Recovery Plan also address watershed-wide processes which will positively affected a wide variety of native species (including other

state and federally listed species) by restoring natural ecosystem functions. In addition, human uses of aquatic habitats such as recreation will benefit from these measures.

Although the recovery of this species is expected to be a long process, the TRT recommended certain actions that should be implemented as soon as possible to help guide the recovery process for the Southern California Steelhead DPS (Boughton *et al.* 2007). Additional and more specific recovery actions to address specific threat sources in individual watersheds are discussed in the text.

Implementation and Cost Estimates

Implementation of this Recovery Plan by NMFS will take many forms. To achieve recovery, NMFS will need to promote the Recovery Plan and provide needed technical information and assistance to other entities responsible for actions that may impact the species' recovery. NMFS should work with key partners on planning and implementation of all high priority recovery actions. Additionally it will be important to work with cities and counties to ensure that protective measures consistent with recovery objectives are included in their General Plans and Local Coastal Plans. NMFS should also work with state and federal regional entities on Regional Water Control Board Basin Plans and U.S. Forest Service Plans.

An implementation schedule describing time frames and costs associated with individual recovery actions is under development. Estimating total cost to recovery is much more challenging, if not impossible to estimate for a variety of reasons. These reasons include the large geographic extent of the SCS Recovery Planning Area; the need to refine recovery criteria; the need to complete watershed-specific investigations such as barrier inventories and assessments; the establishment of flow regimes for individual watersheds; and the review and possible modification of a variety of exiting land-use and water management plans (including waste discharge requirements) under a variety of local, state, and federal jurisdictions. Additionally, the biological response of many of the recovery actions is uncertain, and achieving full recovery will be a long-term effort likely requiring decades, while addressing new stressors that emerge over time. In some instances, however, NMFS is able to estimate the costs associated with certain common restoration activities such as those undertaken as part of the California Department of Fish and Game Fisheries Restoration Grants Program. Appendix E of this document contains estimates for these categories of typical watershed restoration actions.

Nonetheless, the criteria and recovery actions identified in this Recovery Plan provide a comprehensive road-map for recovery and are consistent with many ongoing activities intended to protect and or restore ecosystem functions in southern California watersheds. As a result, many of these recovery actions will be undertaken by local, state and federal agencies, as well as non-governmental organizations and other private entities as a part of their local ecosystem protection efforts. Also, the wide variety of threats to steelhead provide for a variety of potential funding sources available to develop and implement these recovery actions, often as part of other ongoing natural resource restoration, management, and mitigation programs.

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Appendix D – Southern California Steelhead Recovery Planning Area Threats Assessment (Cap Workbook) Methodology

Appendix E – Habitat Restoration Cost References for Salmon Recovery Planning

WHAT IS A RECOVERY PLAN?

The Endangered Species Act (ESA) was signed into law in 1973 for the purposes of conserving the ecosystems upon which species in danger of extinction depend. The National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) is responsible for ESA implementation for listed marine and anadromous species. The Southern California Distinct Population Segment (DPS) of steelhead (*Oncorhynchus mykiss*) is listed as an endangered species under the ESA. As such, the ESA requires NMFS to develop and implement a recovery plan to ensure the survival and recovery of this species. The plight of these fish is severe and unless the causes of their decline are addressed immediately, they will likely go extinct in our children's lifetime.

Recovery is defined as the process of restoring listed species and their ecosystems to the point that they no longer require the protections of the ESA. A recovery plan serves as a road map for species recovery—it lays out where we need to go and how best to get there. Without a plan to organize, coordinate and prioritize the many possible recovery actions on the part of Federal, State, local, and tribal agencies, local watershed councils and districts, and private citizens, our efforts may be inefficient, ineffective, or even misdirected. Prompt development and implementation of a recovery plan will target limited resources effectively. Although recovery plans are guidance documents, not regulatory documents, the ESA clearly envisions recovery plans as the central organizing tool for guiding each species' progress toward recovery.

Recovery plans outline the processes needed to stop or reverse the species' decline, neutralize threats, and bring the species back from possible extinction to a point where the protections of the ESA are no longer necessary.

DOCUMENT GOALS AND ORGANIZATION

The goal of this recovery plan is to provide the framework for recovery and delisting steelhead populations within the Southern California DPS. The ESA mandates application of all methods and procedures which are necessary to provide for the conservation and survival of listed species, to the extent that measures pursuant to the ESA will no longer be necessary. Therefore, the plan conveys:

- An assessment of the threats facing the species, including those identified when the species was listed and any new threats;
- A strategy to achieve recovery that is transparent and adaptable;
- The actions NMFS believes are critical to abating those threats and restoring habitat conditions and species' health; and
- Criteria to measure the achievement of recovery.

Furthermore, it is the intent of the ESA that recovery plans guide Federal agencies in fulfilling their obligations under ESA section 7(a)(1), 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…" This will involve coordinating with Federal agencies, including but not limited to the U.S. Fish and Wildlife Service, in implementing recovery actions. In addition to outlining strictly proactive measures to achieve the species' recovery, recovery plans provide context and a framework for implementation of other provisions of the ESA with respect to a particular species, such as section 7(a) (2) consultations intended to ensure Federal agency activities are not likely to jeopardize listed species or development of section 10(a) (1) (B) Habitat Conservation Plans (HCP).

This recovery plan is structured to provide the reader with (1) an introduction to the species and the recovery planning process, (2) an overview of Southern California DPS steelhead biology and ecology, (3) a discussion of the past, present, and future threats to species' recovery including the listing factors identified in the *Federal Register*, (4) the objectives and specific criteria used to determine species recovery or eligibility for "down listing" or "delisting" under the ESA, (5) the strategy NMFS recommends to focus recovery efforts on foundation populations and essential actions for recovery, (6) NMFS' role in using and implementing the recovery plan for the benefit of the species and its ecosystem, and (7) a presentation of the specific areas, threats and recommended recovery actions needed throughout the DPS to achieve recovery of the species.

1. Introduction

"There is a charm in fishing for trout in the small stream, and this is multiplied a hundred times, with the attendant excitement, for the angler who seeks the great fresh-run steelhead in the little rivers of the Southern California Coast. . . 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."

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

1.1 SOUTHERN CALIFORNIA STEELHEAD AT RISK

Steelhead are the anadromous, or ocean-going, form of the species *Oncorhynchus mykiss.* Historically, these fish were the only abundant salmon species that occurred naturally within the coast ranges of southern California (Jordan and Evermann 1896, 1923; Jordon and Gilbert 1881). Steelhead entered the rivers and streams draining the Coast Ranges from Point Conception to the U.S. Mexican Border during the winter months 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 (Boydstun 1973; Capelli 1974; Combs 1972; Fry 1938, 1973; Hubbs 1946; Kreider 1948; Nehlsen, *et al.* 1991; Shapovalov 1944, 1945; Swift 1993).

Steelhead Anglers, Ventura River Estuary 1909

Following the dramatic rise in southern 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 rest. 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 protected from the impacts of human development. In fact, a substantial portion of these upper watersheds,

which contain the majority of historical spawning and rearing habitats for anadromous *O. mykiss*, remain intact and protected from intensive development as a result of their inclusion in the four large National Forests in southern California: the Los Padres, Angeles, San Bernardino, and Cleveland National Forests.

Our goal is to prevent the extinction of steelhead in the wild and ensure the long-term persistence of self-sustaining, and ultimately harvestable, wild populations of steelhead across the 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.

To recover steelhead, the following objectives have been identified:

1. Prevent steelhead extinction by protecting existing populations and their habitats.
2. Maintain current distribution of steelhead and restore distribution to previously occupied areas that are essential for recovery.
3. Increase abundance of steelhead to viable population levels, including the expression of all life history forms and strategies.
4. Conserve existing genetic diversity and provide opportunities for interchange of genetic material between and within metapopulations.
5. Maintain and restore suitable habitat conditions and characteristics for all life-history stages so that viable populations can be sustained.
6. Conduct research and monitoring necessary to refine and demonstrate attainment of recovery criteria.

1.2 SOUTHERN CALIFORNIA STEELHEAD LISTING HISTORY

After NMFS completed a comprehensive status review of all west coast steelhead populations (Busby, *et al.* 1996), southern California populations were proposed for listing by NMFS as an endangered 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 con-specific populations, and that possess important elements of the evolutionary legacy of the species which are expressed genetically and have adaptive value (Waples 1991, 1995). The Southern California Steelhead ESU was formally listed as endangered on August 18, 1997 (62 FR 43937). The original ESU boundaries during the first listing of 1997 were from the Santa Maria River south to Malibu Creek. Following this initial listing, *O. mykiss* were discovered in watersheds south of Malibu Creek (Topanga Creek in Los Angeles County and San Mateo Creek in Orange County) and genetic testing confirmed that these *O. mykiss* were most closely related to the more northern populations of the Southern California Steelhead ESU. This resulted in the range for the ESU being extended south to the U.S.-Mexico border on May 1, 2000 (67 FR 21586).

Following another status review of west coast steelhead populations in 2005 (Good *et al.* 2005), a final ESA listing determination for the endangered Southern California Steelhead DPS was issued on January 5, 2006 (71 FR 834). During the time between the initial listing and the 2006 listing, NMFS adopted the DPS designation for steelhead to replace the ESU designation in order to be consistent with listing policies utilized by the U. S. Fish and Wildlife Service. The DPS Policy (61 FR 4722) uses similar but slightly different criteria from the ESU Policy for determining when a group of organisms constitutes a DPS. 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" but does not have to exhibit reproductive isolation. The final designation for the Southern California Steelhead DPS encompasses all naturally spawned steelhead between the Santa Maria River (inclusive) and the U.S.-Mexico border. Consequently, this DPS includes only those *O. mykiss* whose freshwater habitat occurs below impassible barriers, whether artificial or natural, and which exhibit an anadromous life history. Individuals that have originated in freshwater above impassible barriers and exhibit an anadromous life history are also considered as part of the DPS when they are within waters below the barrier.

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 Southern California Steelhead DPS are those sites and habitat components that support one or more life stages and contain physical or biological features essential to survival, growth, and reproduction. These PCEs include:

Freshwater spawning sites with sufficient water quantity and quality and adequate substrate (*i.e.*, spawning gravels of appropriate sizes) to support spawning, incubation and larval 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, beaver dams, 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 cover and shelter juveniles.

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 Southern California Steelhead DPS was issued on September 2, 2005 (70 FR 52488). A total of 708 miles of stream habitat were designated as critical habitat from the 32 watersheds within the range of this DPS. Critical habitat for the Southern California Steelhead DPS includes most, but not all occupied habitat from the Santa Maria River in southern San Luis Obispo County to San Mateo Creek in northern San Diego County, but excludes some occupied habitat based on economic considerations and all military lands with occupied habitat. Critical habitat was not designated for most of the watersheds south of Malibu Creek with the exception of San Juan Creek and San Mateo Creek. The stream channels with designated critical habitat are listed in 70 FR 52488.

1.4 THE RECOVERY PLANNING PROCESS

The ESA, as amended (16 U.S.C. 1531 *et seq.*), mandates that NOAA-NMFS develop and implement recovery plans for the conservation and survival of listed species. The Southern California Steelhead DPS was listed as endangered in 1997 under the ESA. The development and implementation of a recovery plan for the Southern California Steelhead DPS is considered vital to the continued persistence and recovery of steelhead in this region.

NMFS has established a "recovery planning area" for the purposes of developing this recovery plan and guiding the implementation of actions to recover this species. The Southern California Steelhead (SCS) Recovery Planning Area extends from the Santa Maria River south to the Tijuana River at the U.S.-Mexico border and includes those portions of coastal watersheds that are at least seasonally accessible to steelhead entering from the ocean and the upstream portions of some watersheds that are currently inaccessible to steelhead due to man-made barriers. NMFS' Southwest Region (SWR) Protected Resources Division (PRD) in Long Beach, California is responsible for the development of the recovery plan for the Southern California Steelhead 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 steps that must be taken to meet these criteria. Although recovery plans provide guidance, they are not regulatory documents. However, the ESA envisions recovery plans as the central organizing tool for guiding the recovery of listed species. Recovery plans also 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 implementing other provisions of the ESA, including consultations on federal agency activities under Section 7(a)(2) and the development of HCPs in accordance with Section 10(a)(1)(B).

Recovery plans are also intended to be used to inform, local, state, as well as 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 which may adversely affect that species. The success of a recovery plan depends upon the cooperation of all stakeholders and planning and regulatory entities to ensure appropriate implementation.

Pursuant to Section 4(f) of the ESA, a recovery plan must be developed for species listed as threatened or endangered, and this plan must be implemented unless it is found not to 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 4);
- A description of site-specific management actions necessary for recovery (see Chapters 7 through 11); and
- Estimates of the time and cost to carry out the recommended recovery measures (see Chapters 7 through 11).

Past recovery plans 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 (NMFS 2006).

The Interim Endangered and Threatened Species Recovery Planning Guidance document (NMFS 2006) 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 Southern California Steelhead DPS. The prioritized threats are then used to guide the identification of specific recovery actions. Chapter 4 summarizes the threats across the DPS and Chapters 8 through 12 provide threats assessment results within different geographic areas of the DPS. The threats assessment methodology is discussed in Appendix D.

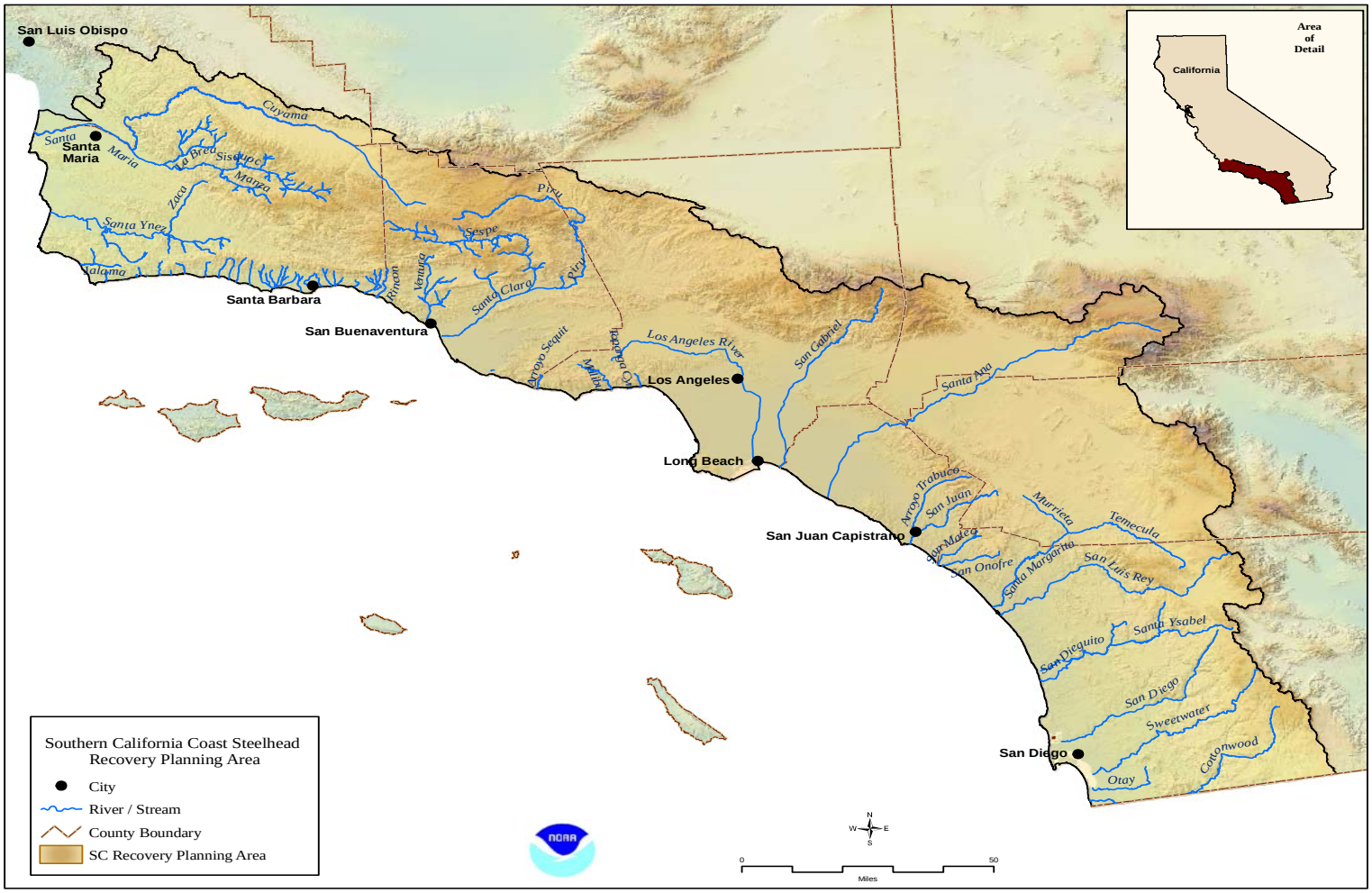

Figure 1-1. Southern California Steelhead Recovery Planning Area. Boundaries of Recovery Planning Area extend beyond the current distribution of the listed species.

1.4.1 Southern California Steelhead Technical Recovery Team

As part of its recovery planning efforts, NMFS SWR assembled a team of scientists with a wide variety of expertise in biological and physical sciences to provide technical assistance to the recovery planning process for southern California steelhead; this group is known as the Technical Recovery Team (TRT). NMFS' intent in establishing the TRT was to seek geographic and species-specific expertise to develop a scientific foundation for the recovery planning. The TRT produced and published a number of Technical Memoranda, which provide a description of the unimpaired historic populations within the Recovery Planning Area (Boughton *et al.* 2006), and identified viability criteria for anadromous *O. mykiss* in the Southern California Steelhead DPS (Boughton *et al*. 2007). Additionally, NOAA Fisheries' Southwest Science Center produced and published a number of additional Technical Memoranda dealing with potential over-summering habitat in the region (Boughton *et al.* 2006), and the reduction of the southern range limit of anadromous *O. mykiss* (Boughton *et al*. 2006). Finally, NOAA Fisheries Southwest Science Center undertook a number of genetic investigations in an attempt to identify the population structure of the Southern California Steelhead DPS, and provided scientific review of local and regional recovery efforts (Girman and Garza 2006, Clemento and Garza 2007).

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 Southern California Steelhead DPS. Public workshops were held in Ventura, California on April 4-5, 2007 and May 31, 2007 and in Carlsbad, California on June 1, 2007 and April 12-13, 2008.

At these workshops, NMFS provided a general overview of:

- The federal recovery planning process;
- The preliminary timeline for NMFS recovery plan development;
- The current understanding of steelhead populations and their habitats;
- An outline of the threats assessment process; and
- A summary of the threats identified during the initial public workshops.

Following the overview, workshop participants were separated into smaller facilitated breakout groups to identify threats to specific steelhead populations and their habitats. In the final set of workshops, breakout groups identified potential recovery actions for specific populations and habitats. Information obtained from these workshops was used in the development of a formal threats assessment analysis using The Nature Conservancy's Conservation Action Planning

(CAP) threats assessment methodology (see Appendix D), and the identification of a full suite of recovery actions based on those threats.

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 (when available) and implementation of recovery actions. The home web page for NMFS SWR salmonid recovery planning is accessible at: http://swr.nmfs.noaa.gov/recovery/index.htm. The web page for recovery planning and implementation for the Southern California Steelhead DPS (including the Recovery Plan, related NOAA Technical Memorandum, and Threats Assessment summaries) can be found at: http://swr.nmfs.noaa.gov/recovery/So_Cal.htm.

Finally, recovery of the species cannot occur without public involvement in the planning and implementation process. NMFS encourages the efforts of watershed groups dedicated to improving watershed ecosystem conditions. NMFS believes it is critically important to base ESA recovery plans for steelhead on the many Federal, State, regional, local, and private conservation efforts already underway throughout the region. Local support of recovery plans 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 recovery plans, involving local communities, State and Federal entities, and other stakeholders. We anticipate that watershed groups and private entities can utilize the information and recommendations provided in this recovery plan to further refine and develop recovery actions to abate threats and meet recovery objectives.

2. Steelhead Biology and Ecology

"[W]e must constantly keep in mind that variation, i.e., deviation from the norm, is one of the most marked characteristics of animal life. And of the vertebrates, the trout are among the most variable of all. Further, of the trout the steelhead is one of the most variable forms. . . . As an example, in the coastal streams most fish migrate in their first year, third, four, 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 seven Pacific salmon in the genus *Oncorhynchus* that are native to the North American coast. O. *mykiss*, along with the other species of Pacific salmon exhibit an anadromous life history, which means that juveniles of the species undergo a change that allows them to migrate to and mature in salt water before returning to their natal rivers or streams (*i.e.,* streams where they were spawned) to reproduce and complete their life cycle.

Two principle recovery objectives are to increase abundance of steelhead, and to preserve the expression of all life-history strategies. An illustration of the various life-history strategies that occur in the Southern California Steelhead DPS is shown in Figure 2-1. These strategies are further discussed in the text below. The figure may be 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 may confer advantages or disadvantages to the survival and success of the individual depending on the conditions of those environments.

Adult steelhead (Figure 2-2) spawn in coastal watersheds and 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 the other Pacific salmon within the genus *Oncorhynchus*.

The life history of steelhead generally involves rearing in freshwater for one to three years before migrating to the ocean and spending two to four years maturing in the marine environment before returning to spawn in freshwater. This life-history strategy is referred to as "fluvial-anadromous," referring to the river or stream focus of the strategy. Out-migration to the ocean (*i.e.,* emigration) usually occurs in the late winter and spring. In some watersheds, juveniles may rear in a lagoon or estuary for several weeks or months prior to entering the ocean. The timing of

emigration is influenced by a variety of factors such as photoperiod, streamflow, temperature, and breaching of the sandbar at the river's mouth. These out-migrating juveniles, termed smolts (Figure 2.4), live and grow to maturity in the ocean for two to four years before returning to freshwater to reproduce.

The ocean phase of steelhead has not been studied extensively, though marine migration studies of other species of *Oncorhynchus* have encountered only isolated specimens of *O. mykiss* and as a result it is believed that the species does not generally congregate in large schools as do other Pacific salmon of the genus *Oncorhynchus* (Burgner *et al*. 1980, 1992; Groot and Margolis 1991). As a result, their movement patterns at sea are poorly understood. Some fish are known to remain in coastal waters relatively close to their natal rivers, while others may range widely in the North Pacific (Quinn 2005).

Returning adults may migrate from several miles to hundreds of miles upstream to reach their spawning grounds. The specific timing of spawning can vary by a month or more among streams within a region, occurring in winter and early spring, depending on factors such as run-off and sand bar breaching. 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 (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. Adults 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 2002). The frequency of repeat spawning among southern California 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 southern California. Additional details regarding this species' life history can be found in Shapovalov and Taft (1954), Barnhart (1986, 1991), Bjornn and Reiser (1991), and Quinn (2005).

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. I*ndividuals 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 and

Reeves (2000) used this technique to uncover occasional life-history switching in *O. mykiss* populations in Oregon. O. *mykiss* in the Southern California Steelhead DPS have not yet been examined in this way, but various lines of evidence (*e.g.*, inland resident fish 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. The cues that trigger this phenomenon are unknown, but may be linked to environmental variation. For example, juvenile residency can be strongly influenced by the hydrologic cycle in southern California, where extended droughts can cause juveniles to become land-locked and therefore unable to reach the ocean (Boughton *et al*. 2006, 2007).

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

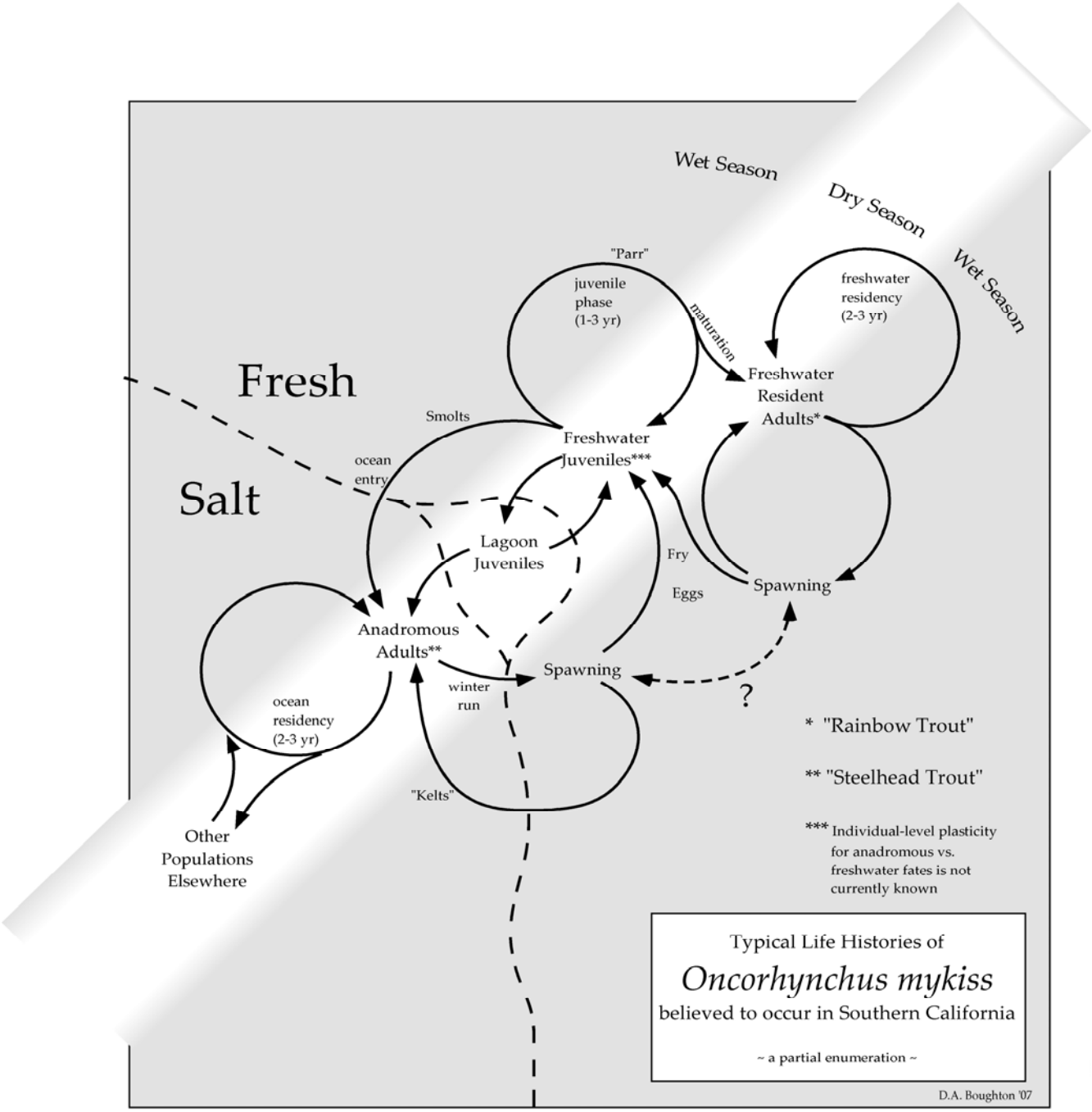

Figure 2-2. Adult female anadromous *O. mykiss* (approx. 75 cm), Carpinteria Creek, Santa Barbara County, 2008.

Figure 2-3. Juvenile *O. mykiss* (approx. 10 cm), Juncal Creek, Santa Barbara County, 2003

Figure 2-4. Steelhead smolt (approximately 17 cm) confluence Ventura River and San Antonio Creek 2008

Lastly, there is a third type of life-history strategy displayed by *O. mykiss* that is referred to as "lagoon-anadromous." Bond (2006), working at a study site in northern Santa Cruz County, has recently shown that each summer a fraction of juvenile *O. mykiss* over-summered in the estuary of their natal creek. Like southern California estuaries, this estuary was cut off from the ocean during the summer by the formation of a sandbar spit, creating a seasonal lagoon. Bond (2006) showed that many juveniles grow fast enough after their first year of lagoon rearing to migrate to

the ocean, and most enter the ocean at a larger size than 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 (Bond 2006).

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; and also so-called "adfluvial" populations that inhabit reservoirs but spawn in tributary creeks.

2.2 SPECIES FRESHWATER DISTRIBUTION AND POPULATION STRUCTURE

Differences between the historical and current distributions of this species illustrate their present endangered status. Many populations have become extirpated, particularly near the southern extent of their range (*i.e.,* in the southern portion of the DPS, south of the Santa Monica Mountains) (Boughton, *et al.* 2005; Xanthippe 2005). Individual populations within this DPS have been severely reduced or in many cases extirpated (Table 2-1, Figure 2-5). Many of the southernmost watersheds may have originally supported sporadic steelhead populations, or intermittent resident populations that experienced repeated local extinctions and recolonizations in dry and wet cycles, respectively.

NMFS conducted an extensive *O. mykiss* population survey in 2002 of most of the coastal watersheds within the Southern California Steelhead DPS (Boughton and Fish 2003). Of the 46 watersheds in which steelhead were known to have occurred historically, between 37 and 43 percent were still occupied by either resident fish or steelhead (a range was reported for the occupancy estimate because several watersheds could not be surveyed). Three watersheds were considered vacant of steelhead because they were dry, 17 were considered vacant due to the presence of impassible barriers to all known spawning habitat, and six were considered vacant because the survey found no evidence of *O. mykiss*. Seventeen watersheds with no known historical record of steelhead occurrence were surveyed; none of these were found to be occupied during the 2002 survey. The distributional study of 2002 also determined that *O. mykiss* was present in two systems (Gaviota Creek and San Mateo Creek) where it was previously reported to be extinct by Nehlsen *et al*. (1991).

One of the recovery objectives of this plan is to maintain current distribution of steelhead and restore distribution to previously occupied areas. Fish-passage barriers appear to have played a large role in watershed-wide extirpations of steelhead; however, in many cases ancestors of sea-run steelhead continue to persist as resident populations above barriers in these same stream systems, and in some cases produce progeny, with exhibit smolt-like characteristics, that emigrate downstream, past the barriers, to the ocean. In an investigation of the contraction of the southern range limit of *O. mykiss*, these populations have been recently documented to occur above barriers in approximately 77 of the instances where steelhead have been lost below the barriers (Boughton *et al.* 2005).

These resident populations could include fish that are considered naturally persistent residents, descendants of steelhead that have been blocked from downstream emigration by barriers and

have been forced to adopt a resident-type life cycle (*i.e.,* "residualized" populations), or perhaps progeny of stocked *O. mykiss* found above barriers to steelhead migration (Boughton et al. 2005).

Table 2-1. Southern California 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.

WATERSHED[1]	CURRENTLY OCCUPIED[2]
Santa Maria River	Yes
Santa Ynez River	Yes
Jalama Creek	Negative obs.[3]
Cañada de Santa Anita	Yes
Cañada de la Gaviota	Yes
Cañada San Onofre	Negative obs.
Arroyo Hondo	Yes
Arroyo Quemado	Barrier[2]
Tajiguas Creek	Barrier
Cañada del Refugio	Negative obs.
Cañada del Venadito	Barrier
Cañada del Corral	Yes
Cañada del Capitan	Negative obs.
Gato Canyon	Not determined
Dos Pueblos Canyon	Yes
Eagle Canyon	Not determined
Tecolote Creek	Yes
Bell Canyon	Barrier
Goleta Slough Complex	Yes
Arroyo Burro	Yes
Mission Creek	Yes
Montecito Creek	Yes
Oak Creek	Barrier
San Ysidro Creek	Yes
Romero Creek	Yes
Arroyo Paredon	Yes
Carpinteria Salt Marsh Complex	Barrier
Carpinteria Creek	Yes
Rincon Creek	Yes
Ventura River	Yes

WATERSHED[1]	CURRENTLY OCCUPIED[2]
Santa Clara River	Yes
Big Sycamore Canyon	Negative obs.
Arroyo Sequit	Yes
Solstice Creek	Yes
Malibu Creek	Yes
Topanga Canyon	Yes
Los Angeles River	Yes
San Gabriel River	Yes
Santa Ana River	Barrier
San Juan Creek	Yes
San Mateo Creek	Yes
San Onofre Creek	Dry
Santa Margarita River	Negative obs.
San Luis Rey River	Yes
San Dieguito River	Yes
Sweetwater River	Yes
Otay River	Barrier
Tijuana River	Not determined

[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. *(2006); Sleeper (2002); Titus* et al. *(2006); M. Larson, California Department of Fish and Game, personal communication (2007).*

[3] *"Negative obs." means juveniles were not observed during a spot-check of best-occurring summer habitat in 2002. "Dry" indicates the stream had no discharge in anadromous reaches during the summer of 2002. "Barrier" indicates that all over-summering habitat was determined to be above an anthropogenic barrier, believed to be impassable, and therefore steelhead were not expected to be present. See Boughton* et al. *(2005)*.

Several reports describe the historical populations of the Southern California Steelhead DPS (Boughton *et al*. 2005; Boughton and Goslin 2006; Boughton *et al*. 2006, 2007). Using this information, the TRT proposed a structure for the Southern California Steelhead DPS that breaks into five Biogeographic Population Groups (BPGs) (Table 2-2). The division of steelhead populations into Biogeographic Population Groups utilized two basic rules: First, populations were sorted into a coastal super-group and an inland super-group, based on whether or not the most potential freshwater habitats lay on an ocean-facing watershed subject to marine based climate inversion and orographic precipitation from off-shore weather systems. Second, within the coastal and inland super-groups, populations were sorted into groups defined by contiguous areas with broadly similar physical geography and hydrology. The combinations of these

physical characteristics represent differing natural selective regimes for steelhead populations utilizing the individual watersheds. These differing physical characteristics have lead to life-history and genetic adaptations that can enable the populations to persist in widely varying habitat regimes represented by the Biogeographic Population Groups. The purpose of delineating the BPGs is to guide recovery efforts across the DPS to ensure the preservation and recovery of the range of natural diversity of the Southern California Steelhead DPS. From north to south, these BPGs are known as: Monte Arido Highlands, Conception Coast, Santa Monica Mountains, Mojave Rim, and Santa Catalina Gulf Coast (Figure 2-5).

Table 2-2. Ecological characteristics of BPGs in the Southern California steelhead DPS (originally Table 4 in Boughton et al. 2007).

Southern California Steelhead ESU

Population Group	Ecological Characteristics				
	Migration Corridor	Migration reliability	Summer Climate Refugia	Intermittent Streams	Winter Precipitation
Monte Arido Highlands	Long alluvial valleys	Moderate/ Low	Montane	Many	60 – 75 cm (highlands)
Conception Coast	Coastal terrace	Moderate	Marine	Many	30 – 60 cm
Santa Monica Mountains	Short, steep	Low	Marine	Many	30 – 60 cm
Mojave Rim	Long alluvial valleys	Very Low	Montane	Many	75 – 135 cm (highlands)
Santa Catalina	Coastal terrace	Low	Marine	Many	mostly <75 cm
Gulf Coast	& mesas				

The separate watersheds comprising each BPG are generally considered as individual *O. mykiss* populations (*i.e.,* one watershed = one population of steelhead). Thus, single BPGs encompass multiple watersheds and multiple *O. mykiss* populations. However, many coastal watersheds in several of the BPGs (*e.g.*, Conception Coast, Santa Monica Mountains) are relatively small, and may be capable of supporting only small steelhead runs. The basis for the persistence of independent steelhead populations in these small watersheds is uncertain and further research is needed. The TRT (Boughton *et al.* 2007) propose that at least three scenarios (not necessarily mutually exclusive) are plausible:

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

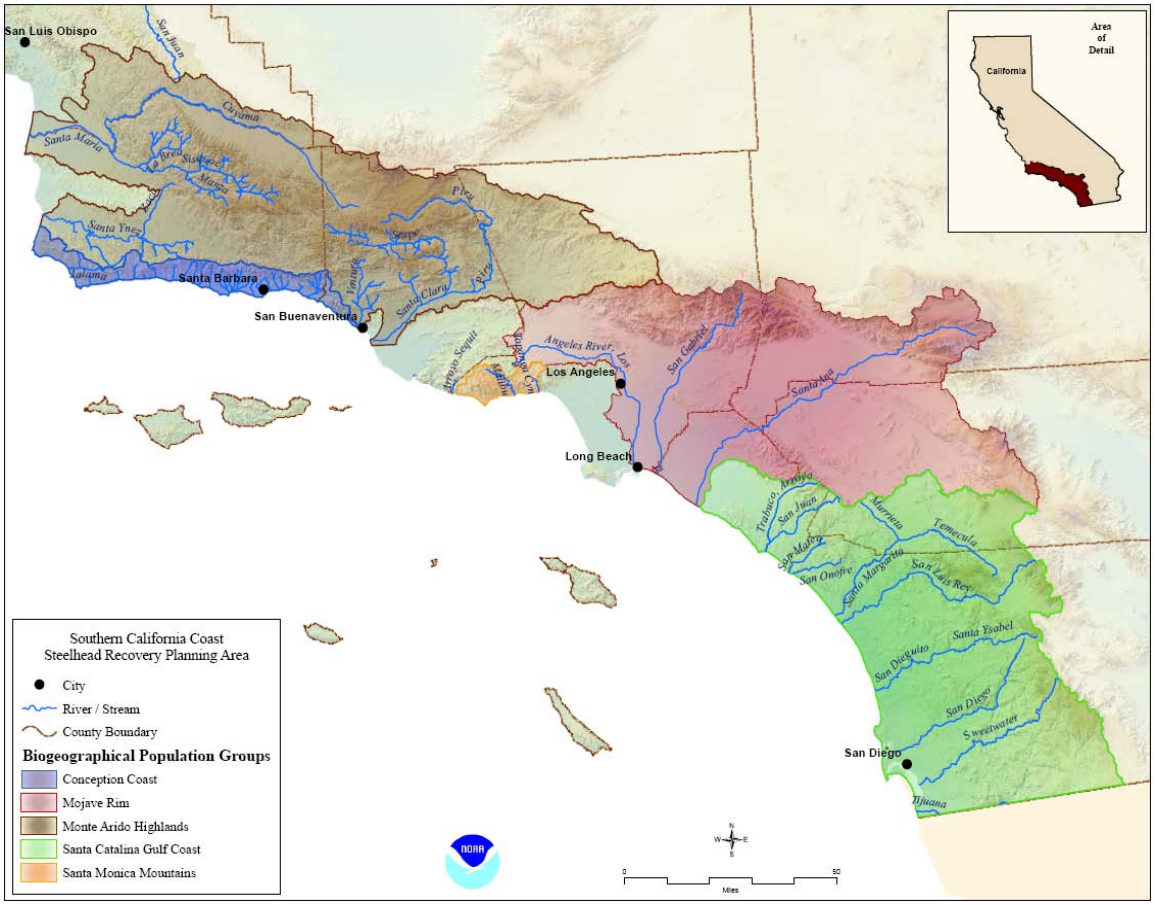

Figure 2-5. Biogeographic Population Groups (BPGs) in the Southern California Steelhead Recovery Planning Area (after Boughton *et al*. 2007).

In characterizing the historic, pre-European settlement population structure of the Southern California Steelhead DPS, the TRT: 1) identified the original anadromous *O. mykiss* populations and attempted to determined 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. This analysis entailed a consideration of available historical and current data on the distribution and abundance of *O. mykiss*, new genetic data, landscape data, climate data, and stream discharge data. However, data limitations, particularly a lack of long-term run-size data, prevented the TRT from providing definitive characterizations of pre-European or current anadromous *O. mykiss* populations, including the geographic extent of individual populations, their intrinsic viability, or demographic independence. For a discussion of the constraints imposed by limited relevant data see Boughton *et al*. (2006) and see Appendix B for relative viability rankings of populations, and Appendix C for populations grouped by BPG.

2.3 SPECIES ABUNDANCE

One of the recovery objectives for steelhead is to increase abundance of steelhead, including the expression of all life history forms and strategies. Current population abundances are extremely small, with no watersheds currently exhibiting annual runs of returning adults of more than a dozen fish, at most, in recent years, and the presence of steelhead in watersheds is often sporadic (Busby *et al.* 1996; Good *et al*. 2005). It has been estimated that the steelhead populations in this region have declined dramatically from annual runs totaling between 32,000 and 46,000 adults to less than 500 total adults (Busby *et al*. 1996). However, this run-size estimate is based on information from only the four major watersheds bearing steelhead (Santa Ynez River, Ventura River, Santa Clara River, and Malibu Creek) located in the northern portion of the SCS Recovery Planning Area. Run-size estimates from coastal and inland watersheds south of the Los Angeles Watershed have generally not been estimated or recorded. Additionally, available run-size estimates represent only average annual estimates, and do not describe the wide annual variation in run-size that would be expected in a region with a highly variable climate and habitat conditions. Quantitative estimates historic of historic runs in the Southern California Steelhead DPS are based largely on observations made by California Department of Fish and Game (CDFG) personnel. No long term (20+ years) time-series data are available for any of the populations within this DPS. Since the listing of southern California steelhead, there have been increased efforts made to make periodic observations of adults as well as more systematic monitoring on a few major watersheds with recently constructed fish passage facilities (*e.g.*, Robles Diversion on the Ventura River and Vern Freeman Diversion on the Santa Clara River).

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 1980s, a number of genetic studies have been conducted to clarify the structure of *O. mykiss* populations within the Southern California Steelhead DPS. These studies have provided useful insights into the historic distribution of the species, as well as the potential influence of past (and current) stocking

practices within the watersheds historically occupied by native *O. mykiss. B*erg and Gall (1988) surveyed steelhead populations throughout California, including a small number of populations from the Southern California Steelhead DPS. 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 Southern California Steelhead DPS. Busby *et al.* (1996) also found 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.

Recent genetic investigations have shed light on the relationship between steelhead and the *O. mykiss* above barriers within the Southern California Steelhead DPS. Girman and Garza (2006) determined that above barrier *O. mykiss* were more closely associated with below-barrier populations than to populations from other watersheds; that they were more related to the fish below the barrier than to any other 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 descendents of hatchery fish. They are most likely the descendents of contiguous *O. mykiss* populations, because most of these areas have historical accounts of steelhead populations prior to construction of the barriers. While the fish that remain above barriers do not have an opportunity to interbreed with sea-run steelhead, they can and in some cases do produce progeny, with exhibit smolt-like characteristics, that emigrate downstream, past the barriers, to the ocean.

A more recent genetics study of *O. mykiss* in the Santa Ynez River reaches similar conclusions (Garza and Clemento 2007). The major conclusions of the study included: 1) the spatial genetic structure of the Santa Ynez River watershed was similar to most other coastal watersheds; 2) the estimated effective population size[1] in two tributaries varied between approximately 25-50 individuals; 3) there were significant differences between populations from four sub-watersheds (Salsipuedes, Juncal, Santa Cruz, and Hilton Creeks); and 4) all four populations (two below and two above barriers to anadromy) are primarily of coastal ancestry.

2.5 HABITAT CHARACTERISTICS OF THE SOUTHERN CALIFORNIA STEELHEAD RECOVERY PLANNING AREA

The major watersheds of the planning area include the Santa Maria, Santa Ynez, Ventura, and Santa Clara Rivers, all of which are located in the northern portion of the SCS Recovery Planning Area (Busby *et al*. 1996; Good *et al*. 2005). South of the Santa Monica Bay, several major drainages and a number of smaller streams once supported runs of anadromous *O. mykiss* (of unknown size and frequency); these include the Los Angeles, San Gabriel, Santa Ana, Santa Margarita, San Luis

[1] The effective population size (N_e) can be generally thought of as the number of individuals that contribute offspring to the next generation, and is generally smaller than the absolute population size (N). It is a basic parameter in many models in population genetic.

Rey, San Dieguito, San Diego, Sweetwater Rivers, and San Juan and San Mateo Creeks (Swift *et al.* 1993; Titus *et al*. 2006).

Significant portions of the upper watersheds within the SCS Recovery Planning Area are contained within four national forests (Los Padres, Angeles, Cleveland, and San Bernardino National Forests). These forests are managed primarily for water production and recreation (with limited grazing and oil, gas, and mineral production). Urban development is centered in coastal areas and inland valleys, with the most expansive and densest urban development located within the Los Angeles Watershed. Coastal valleys, and some foothills, are extensively developed with agriculture, principally row-crops, citrus and fruit trees, and vineyards (Hornbeck 1983; Keeley1993; Lantis *et al*. 1981; Lockmann 1981; Stephenson and Calcarone 1999; U.S. Forest Service 2006).

The SCS Recovery Planning Area is characterized by geologically young mountainous topography with a number of inland valleys and coastal terraces. The geomorphology (*i.e.,* the shape and composition of the land) 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 type over time) in the Central Coast Ranges, sedimentary formations (*i.e.,* formations comprised of sediment deposited out of the air, ice, wind, gravity and/or water flows) in the Transverse Ranges, and metamorphic-granite formations (*i.e.,* igneous rock formed from cooled magma) in the southern Peninsular Ranges. The legacy of tectonic activity and other physical stresses has created the steep slopes and unconsolidated rock formations that characterize this region. These geologic factors combined with an active, annual fire-cycle and intense winter storms have created spatially complex and frequently unstable river and stream habitats where anadromous fishes and other aquatic species live (Bailey 1966; Faber *et al*. 1989; Felton 1965; Norris and Webb 1990; Norris 2003; Sugihara *et al.* 2006).

The SCS 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 Southern California Conifer Forests (Barbour, *et al*. 2007; Ferren *et al*. 1995; Hickman 1993; Munz 1974; Sawyer and Keeler-Wolf 1995). Upland areas of the northern portion of the SCS Recovery Planning Area are dominated by a mix of Chaparral, Valley Grasslands, Oak Woodlands, and Southern California Conifer Forests. Upland areas of the southern portion of the SCS Recovery Planning Area are dominated by Southern Coastal Scrub, Valley Grassland, Oak Woodland, and Southern California Conifer Forests. Both of these upland areas are subject to catastrophic wildfires (Sugihara *et al.* 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 (Barbour *et al*. 2007; California Department of Fish and Game 2003; Holland 1996; Kreissman 1991; Mayer and Laundenslayer 1988; Stephenson and Calcarone 1999; Warner and Hendrix 1984). However, the interior uplands within the four National Forests are largely undeveloped, and a number of large parks, preserves, and greenbelts have been created in recent years on non-Federal lands.

The climate in the California floristic province is Mediterranean, with long dry summers and short, sometimes intense cyclonic winter storms. Rainfall is restricted almost exclusively to the winter months (December through March), though the extreme southern portion of the SCS Recovery Planning Area is subject to occasional summer storms originating from the Gulf of California. The California floristic province is subject to an El Niño/La Niña weather cycle which can significantly affect winter precipitation, causing highly variable rainfall between years. Additionally, there is a wide disparity between winter rainfall from north to south, as well as between coastal plains and inland mountainous areas. Mean annual precipitation ranges along the coast (north to south) from 32 to 24 centimeters (cm) per year, with larger variations (24-90 cm/year) from the coast inland (west to east) due to the orographic (i.e., lifting) 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 (Bailey 1966; Barbour *et al*. 2007; Felton 1965; Hornbeck 1983; Karl 1979).

River flows vary greatly between seasons, and can be highly flashy during the winter season, changing by several orders of magnitude over a few hours in response to winter storms. Snow accumulation is generally small and of short duration, and does not contribute significantly to peak run-off. Base flows 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 base flow patterns (alternating channel reaches with and without surface flow) controlled by geologic formations, and a strongly seasonal precipitation pattern characteristic of a Mediterranean climate. Water temperatures are generally highest during summer months, but can be locally controlled by springs, seeps, and rising groundwater, creating micro-aquatic conditions suitable for salmonids (Boughton, et al. 2008; Faber et al. 1999; Harrison et al. 2005; Jacobs 1993; Mount 1995; Reid and Wood 1976).

3. Factors Leading to 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

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

The five listing factors are:

A. Present or Threatened Destruction, Modification, or Curtailment of Habitat or Range;

B. Over-Utilization for Commercial, Recreational, Scientific, or Educational Purposes;

C. Disease and Predation;

D. Inadequacy of Existing Regulatory Mechanisms; and,

E. Other Natural or Human-Made Factors Affecting Continued Existence.

NMFS' listing determinations (65 FR 36074, June 7, 2000; 64 FR 14517, March 25, 1999; 63 FR 42588, August 10, 1998; 63 FR 13347, March 19, 1998; 62 FR 43937, August 18, 1997), and supporting technical reports (*e.g.*, Busby *et al.*, 1996; NMFS, 1996) have provided a detailed discussion of the factors affecting steelhead at the time of listing. There was no single factor solely responsible for the decline of southern California steelhead; however, of these factors, the destruction and modification of habitat and natural and man-made factors had been identified as the primary causes for the decline of the Southern California Steelhead DPS.

In this chapter, we present a summary of the factors identified at the time of the listing of the species. All of these factors are still persistent and there have been few changes to the factors

affecting the species since the time of listing. The following chapter, Chapter 4, discusses the current threats facing the Southern California Steelhead DPS and represents our current understanding of how the listing factors continue to affect the species.

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

Southern California steelhead declined in large part as a result of agriculture, mining, and urbanization activities that have resulted in the loss, degradation, simplification, and fragmentation of habitat. 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. In addition to these indirect effects these structures have also resulted in increased direct mortality of adult and juvenile steelhead. Land-use activities associated with urban development, mining, agriculture, ranching, and recreation have significantly altered steelhead habitat quantity and quality. Associated impacts of these activities include: alteration of stream bank and channel morphology; alteration of ambient stream water temperatures; degradation of water quality; elimination of spawning and rearing habitats; fragmentation of available habitats; elimination of downstream recruitment of spawning gravels and large woody debris; removal of riparian vegetation resulting in increased stream bank erosion; and increased sedimentation input into spawning and rearing areas resulting in the loss of channel complexity, pool habitat, suitable gravel substrate, and large woody debris. In addition, a significant percentage of estuarine habitats have been lost across the range of the DPS with an average of 22 percent of estuarine habitat remaining. The condition of these remaining wetland habitats is largely degraded, with many wetland areas at continued risk of loss or further degradation. Although many historically harmful practices have been halted, much of the historical damage remains to be addressed, and the necessary restoration activities will likely require decades. Many of these threats are associated with most of the larger river systems such as the Santa Maria, Santa Ynez, Ventura, Santa Clara, Los Angeles, San Gabriel, Santa Ana, Santa Margarita, San Luis Rey, San Dieguito, and San Diego rivers, and many also apply to the smaller coastal systems such as Malibu, San Juan, and San Mateo creeks.

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

NMFS had previously concluded that recreational harvest is a limiting factor for Southern California steelhead (Busby, *et al.* 1996, 1997; Good, *et al.* 2005; NMFS 1996a). 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 – thought Steelhead are not targeted in commercial fisheries - but 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. Sport and commercial harvest of steelhead in the ocean is prohibited by CDFG (California Department of Fish and Game 2007).

Steelhead populations traditionally supported an important recreational fishery throughout their range. Recreational angling for both winter adult steelhead and summer rearing juveniles is a popular sport. Recreational angling in coastal rivers and streams for native steelhead has increased the mortality of adults (which represent the current generation of brood stock) and juveniles (which represent the future generations of brood stock). During periods of decreased habitat availability (*e.g.*, drought conditions or summer low flow when fish are concentrated in freshwater habitats), the impacts of recreational fishing on native anadromous stocks may be heightened.

Until the listing of the Southern California Steelhead DPS as endangered, recreational angling for *O. mykiss* was permitted in all coastal drainages (and continues in areas above barriers, such as major dams, which are currently impassible to fish migrating upstream). Angling for both adults and juveniles in those portions of coastal rivers and streams accessible to anadromous runs from the ocean (with the notable exceptions of Sisquoc, Manzana, and Davy Brown Creeks in Santa Barbara County, and upper portions of Sespe Creek in Ventura County) has been eliminated through modification of the CDFG's angling regulations following the listing of the DPS as endangered in 1997.

3.3 FACTOR C: 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; Rucker *et al*. 1953; Wood 1979). Very little current or historical information exists to quantify changes in infection levels and mortality rates attributable to these diseases for steelhead. However, studies have shown that native fish tend to be less susceptible to pathogens than hatchery cultured and reared fish (Buchanon *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 (NMFS 1996a). Non-native species, particularly fishes and amphibians such as basses and bullfrogs have been introduced and spread widely. These species can prey upon rearing juvenile steelhead, compete with native juvenile steelhead for living space, cover, and food, and can also act as vectors for non-native diseases.

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 DPS was in danger of extinction, or likely to become so in the foreseeable future, because of disease or predation.

3.4 FACTOR D: 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 Southern California Coast Steelhead DPS (NMFS 1996b, 1997). These included: 1) land management practices within the four U.S. National Forests within the DPS (Los Padres, Angeles, San Bernardino, and Cleveland); 2) the regulation of dredging and the placement of fill within the waters of the United States by the U.S. Army Corps of Engineers (USACE) through the Clean Water Act (CWA) Section 404 Program; 3) the Federal Emergency Management Agency (FEMA) administration of a Flood Insurance Program which strongly influences the development in waterways and floodplains; and 4) inadequate implementation of the CWA sections 303(d)(1)(C) and (D) to protect beneficial uses associated with aquatic habitats, including fishery resources, particularly with respect to non-point sources of pollution (including increased sedimentation from routine maintenance and emergency flood control activities within the active channel and floodplain).

For example, the USACE's program is implemented through the issuance of a variety of Individual, Nation-Wide 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 policy direction, resulted in ineffective protection of aquatic habitats important to migrating, spawning, or rearing steelhead. The deficiencies of the current program are particularly acute during large-scale flooding events, such as those associated with El Niño conditions, which can put additional strain on the administration of the CWA Section 404 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 southern California, and the critical role that margins of active waterways (riparian areas) play in the maintenance of aquatic habitats. In addition, FEMA programs for repairing flood related damages (Public Assistance Program, Individual and Households Program, and Hazard Mitigation Grant Program) promote the replacement of damaged facilities and structures in their original locations, which are prone to repeated damage from future flooding, and thus lead to repeated disturbance of riparian and aquatic habitats important to migrating, spawning, or rearing steelhead.

3.4.2 Non-Federal Mechanisms

At the time of listing, several principal non-federal regulatory and planning mechanisms affected the conservation of steelhead populations within the Southern California Steelhead DPS (NMFS 1996b, 1997). These included: 1) administration of the California State Water Resources Control Board (SWRCB) water rights permitting system which controls utilization of waters for beneficial uses throughout the state; 2) state and local government permitting programs for land uses on non-federal and non-state owned lands; 3) administration of the Fish and Game Code Section 1600 (Streambed Alteration Agreements) program; 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 explicit regulatory mechanism to implement the CDFG Code Section 5937 requirement to protect fish populations below impoundments. Additionally, SWRCB generally lacks the oversight and regulatory authority over groundwater development comparable to surface water developments for out-of-stream beneficial uses.

The Section 1600 Streambed Alteration Agreements program is the principal mechanism through which the CDFG provides protection of riparian and aquatic habitats. Inadequate funding, staffing levels, training, and administrative support have led to inconsistent implementation of this program, resulting in inadequate protection of riparian and aquatic habitats important to migrating, spawning and rearing steelhead.

Finally, monitoring of stocks (particularly annual run-sizes) is essential to assess current and future status of the listed species as well as to develop basic ecological information about listed salmon and steelhead. However, the Coast-Wide Anadromous Fish Monitoring Plan remains unfinished and funding for its implementation has not been identified or secured.

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

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

3.5.1 Environmental Variability

Variability in natural environmental conditions has both masked and exacerbated the problems associated with degraded and altered riverine and estuarine habitats. Floods and persistent drought conditions have reduced already limited spawning, rearing, and migration habitats. 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 offset poor habitat conditions elsewhere and result in dramatic increases in population abundance and productivity.

3.5.2 Stocking Programs

There are no steelhead hatcheries operating in or supplying hatchery reared steelhead to the Southern California Steelhead DPS. However, there is an extensive stocking program of hatchery cultured and reared, non-anadromous *O. mykiss* which supports a "put-and-take" fishery that is stocked for removal by fishermen. These stockings are now generally conducted in non-

anadromous waters (though other non-native game species such as smallmouth bass and bullhead catfish are stocked into anadromous waters by a variety of public and private entities).

While some of these programs have succeeded in providing seasonal fishing opportunities, the impacts of these programs on native, naturally-reproducing steelhead stocks are not well understood. Competition, genetic introgression, and disease transmission resulting from hatchery introductions may significantly reduce the production and survival of native, naturally-reproducing steelhead. Collection of native steelhead for hatchery broodstock purposes can harm small or dwindling natural populations. Artificial propagation can also, in some situations, play an important role in steelhead recovery through carefully controlled supplementation programs, but are not a substitute for naturally-reproducing populations.

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 mainstem of impaired watersheds, while the upper mainstem and tributaries retain relatively high habitat values for steelhead."

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

Anadromous *O. mykiss* in southern 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 throughout a range of environmental conditions. In addition, the persistence and recovery of the species is threatened by predicted shifts in climatic and oceanographic conditions that the species may not be able to survive given the current condition of the species and the freshwater and estuarine ecosystems.

Table 4-1 summarizes the top-ranked[2] sources of threats across the range of the DPS. These were identified as part of the threats assessment performed for watersheds within each BPG. The threat sources with a "very high" or "high" severity ranking within the largest percentage of the watersheds across the DPS are dams and surface water diversions, wildfires, and groundwater extraction. Urban development, levees and channelization, and other passage barriers also affect a large percentage of steelhead watersheds in the DPS. Finally, while not captured in the structured threats assessment process that ranked the other threats to the species (by threat source categories associated with Biogeographic Population Groups), the impacts of environmental variability, including projected changes in precipitation patterns and the consequences of fluctuations in ocean conditions play a significant role in the persistence and recovery of the Southern California Steelhead DPS and are dealt with in Section 4.2.5.

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.

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

4.1 THREATS ASSESSMENT PROCESS

NMFS assessed the current and expected future threats to the species' persistence and recovery primarily through the use of The Nature Conservancy's Conservation Action Planning (CAP) methodology. This methodology and NMFS' application to the threats assessment for southern California steelhead is further detailed in Appendix D. Use of this methodology allows NMFS to organize the best available information and professional judgment on the threats facing the species into electronic workbooks that are programmed to summarize and track the information for use in developing and implementing recovery actions designed to address the identified threats. The threats assessment process is intended to be iterative so that new information can be incorporated as it becomes available or as periodic status reviews of the species occur.

Current conditions of critical habitat elements for steelhead were assessed given available information from a variety of sources including published and unpublished reports. The severity of threats posed directly 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 range of the DPS, within each BPG, and within specific watersheds were identified. A listing of the individual watersheds that were evaluated in the CAP workbooks that were used to summarize threats at these scales can be found in Appendix D.

In addition to the CAP threats assessment process, NMFS considered the best available information regarding the impacts of predicted shifts in climate and the marine environment on the ability of the species to recover. These two threats are not easily reflected in the CAP workbooks and so do not show up in the tables depicting the threats assessments results below. However, NMFS considers the threats posed by shifting climate and a varying marine environment when recommending a recovery strategy for the species and particular recovery actions. The primary method by which the species will be able to persist and recover in the face of changing environmental conditions in the freshwater or marine environment is the achievement of viable levels of abundance within well-distributed populations across a landscape of accessible habitats that support the different life stages and strategies used by the species. Recovery actions to address climate and marine environmental conditions are therefore embedded within recovery actions designed to support these objectives.

4.2 CURRENT DPS-WIDE THREATS ASSESSMENT SUMMARY

The following discussion presents the available information on the current and future threats faced by the species. The discussion is organized around the threat sources listed above. The information presented in this chapter is a summary of the threats faced by the species across the range of the DPS. Specific information on threats within the different BPGs is presented in BPG-specific chapters and associated appendices.

The overall current conditions of 45 major watersheds within the SCS Recovery Planning Area were generally rated as "Fair" to "Poor" (see CAP Workbook summaries for more detailed information). Only four of the 45 watersheds analyzed were rated with an overall condition of

Table 4-1. High or Very High severity threat sources identified for the SCS Recovery Planning Area by BPG. Percentages reflect the percent of component watersheds that ranked the threat source as "Very High" or "High." See individual BPG Threat Summaries in their respective chapters for additional information.

	Biogeographic Population Group (BPG)					
Threat Source*	**Monte Arido Highlands**	**Conception Coast**	**Santa Monica Mountains**	**Mojave Rim**	**Santa Catalina Gulf Coast**	**Average Percentage Affected**
Dams and Surface Water Diversions	**85%**	**30%**	**20%**	**88%**	**90%**	**63%**
Wildfires	**85%**	**50%**	**20%**	**75%**	**60%**	**58%**
Groundwater Extraction	**62%**	**60%**		**63%**	**100%**	**57%**
Urban Development	**62%**	**40%**	**20%**	**63%**	**70%**	**51%**
Levees and Channelization	**38%**	**50%**	**20%**	**63%**	**60%**	**46%**
Other Passage Barriers	**8%**	**80%**	**60%**	**13%**	**40%**	**40%**
Flood Control	**62%**	**20%**		**88%**	**20%**	**38%**
Roads	**15%**	**60%**	**100%**		**10%**	**37%**
Agricultural Development	**62%**	**40%**			**60%**	**32%**
Recreational Facilities	**31%**	**30%**	**60%**		**30%**	**30%**
Non-Native Species	**54%**		**20%**		**30%**	**21%**

"Good" or "Very Good" (due in some cases to relatively good access to spawning and rearing habitats) in the CAP Workbook analyses: San Antonio Creek and Santa Paula Creek in the Monte Arido Highlands BPG, Arroyo Hondo in the Conception Coast BPG, and Topanga Canyon Creek in the Santa Monica Mountains BPG. Many of the watersheds contain high-quality spawning and rearing habitat, but are compromised by one or more anthropogenic factors (*e.g.*, Matilija Creek [dam], North Fork Matilija Creek [other passage barriers], and Sespe Creek [excessive groundwater extraction and diversions in the lower reaches] in the Monte Arido Highlands BPG). A widespread trend observed in the SCS Recovery Planning Area is severe to very severe degradation of habitat conditions along the mainstem of impaired watersheds, while the upper mainstem and tributaries retain relatively high habitat values for steelhead.

4.2.1 Dams, Surface Water Diversions and Groundwater Extraction

Dams, surface water diversions, and groundwater extraction are common across the SCS Recovery Planning Area, especially on the larger rivers, such as the Santa Maria, Santa Ynez, Ventura, Santa Clara (tributaries), San Gabriel, and Santa Ana rivers, some of which contain three major dams on the mainstem alone. Loss of surface flows or other passage impediments along the mainstem of the river affects important upstream tributaries in terms of providing spawning and rearing habitat, even if the tributaries themselves remain undisturbed. Re-establishing or maintaining connections between the ocean and upper watersheds expands access to historically important spawning and rearing habitats, and significantly improves habitat conditions in these watersheds for steelhead, as well as the existing populations of native residualized and non-anadromous *O. mykiss* that currently are isolated above dams and reservoirs.

Dams also negatively affect the hydrology, sediment transport processes, and geomorphology of the affected drainages. In addition, dams and reservoirs frequently include recreational development for fishing and camping, which can introduce non-native predators and/or competitors (*e.g.*, largemouth bass, crayfish, western mosquitofish) as well as promote trampling of the active channel, which can lead to direct loss of redds.

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

Human population density is high in some parts of the SCS Recovery Planning Area and development pressures in general are located in the coastal terraces and middle and lower watershed areas. Population density is a relative measure of intensity of land use and impacts to individual watersheds. Some of these watersheds have been extensively developed for agriculture, which typically utilizes floodplain land first. In addition, the upland slopes in several of the watersheds in the Conception Coast BPG and Santa Catalina Gulf Coast BPG are extensively planted in orchard crops. 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. Public ownership of lands in the SCS Recovery Planning Area varies widely between watersheds but generally decreases southward. Although public ownership of these watersheds (National Forest and BLM lands, military reservations, *etc.*) can be extensive, these public lands are typically concentrated in the upper watersheds leaving the middle and lower watersheds subject to private development.

Estuaries are used by steelhead as rearing areas for juveniles and smolt as well as staging areas for smolt acclimating to saline conditions in preparation for entering the ocean and adults acclimating to freshwater in preparation for spawning. Approximately 75 percent of estuarine habitats across the SCS Recovery Planning Area have been lost (Table 4-2), and the remaining 25 percent are constrained by agricultural and urban development, levees, and transportation corridors highways and railroads. Estuarine habitat loss varies widely across BPGs, with the Santa Maria River and Santa Ynez River estuaries being the most physically intact, though they are impaired by reduced freshwater inflows and point and non-point waste discharges from both municipal and agricultural sources.

4.2.3 Flood Control, Levees and Channelization

Urban and agricultural conversion of floodplain lands flanking the mainstem of these rivers and streams typically requires levees or other structures to protect these lands from flooding. The urban and agricultural reaches of all of the watersheds in the SCS Recovery Planning Area have been subjected to some degree of channelization and/or levee construction with the resulting loss or degradation of the riparian corridor and streambed. Flood control practices and associated channelization of streams and placement of levees impair the function and quality of stream habitats. 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.

4.2.4 Non-Native Species

There are no steelhead hatcheries operating in or supplying hatchery reared *O. mykiss* to the Southern California Steelhead DPS. However, there is an extensive stocking program of hatchery cultured and reared, non-anadromous *O. mykiss* that supports a put-and-take fishery. These stockings are now generally conducted in non-anadromous waters. 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. While some of these programs have succeeded in providing seasonal fishing opportunities, the impacts of these programs on native, naturally-reproducing *O. mykiss* stocks are not well understood. Competition and disease transmission resulting from hatchery introductions may significantly reduce the production and survival of native, naturally-reproducing steelhead. Collection of native steelhead for hatchery broodstock purposes can also harm already small or dwindling natural populations. Artificial propagation, in some situations, can play an important role in steelhead recovery through carefully controlled supplementation programs, but they are not a substitute for naturally reproducing populations.

California's steelhead stocking practices have distributed non-native steelhead stocks in many coastal rivers and streams in California. Because of problems associated with the practice of transplanting non-native steelhead stocks, CDFG developed its Salmon and Steelhead Stock Management Policy. This policy recognizes that such stock mixing can be detrimental and seeks to maintain the genetic integrity of all identifiable stocks of salmon and steelhead in California, as well as minimize interactions between hatchery and natural populations. To protect the genetic integrity of individual salmon and steelhead stocks, this policy directs CDFG to evaluate the stocks of each salmon and steelhead stream and classify it according to its probable genetic

source and degree of integrity (McEwan and Jackson 1996). Additionally, CDFG has eliminated the stocking of hatchery cultured and reared fish in most coastal streams where steelhead have direct access from the ocean.

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 southern California 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 Santa Clara and San Luis Rey River drainages, 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.*

4.2.5 Estuarine Loss

The mouths of most southern California 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 (Ferren *et al.* 1995). 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 southern California, they have been subjected to a majority of the DPS-wide threats identified through the threats assessment. Estuarine functions have been adversely affected in a wide variety of ways (*e.g.*, degradation of water quality, modification of hydrologic patterns, changes in species composition), but the single best indicator of the threat to estuarine functions is loss of wetland acreage, through a range of activities, including filling, diking, and draining. Table 4-2 provides a summary of the relative loss of southern California wetland estuarine acreage for some of the estuaries associated with steelhead populations in southern California for which information was available. (See Chapter 2, "Steelhead Biology and Ecology" and the discussion below for the role of estuaries in the life history of southern California steelhead).

Table 4-2. Estuarine habitat loss in component watersheds of the SCS Recovery Planning Area by BGP.

BPG	Watershed	Remaining Estuarine Habitat (% of historical habitat)	BPG Average
Monte Arido Highlands	Santa Maria River	81	*56% remaining*
	Santa Ynez River	94	
	Ventura River	32	
	Santa Clara River	15	
Conception Coast	Gaviota Creek	25	*6% remaining*
	Arroyo Hondo	5	
	Tecolote Creek	25	
	Goleta Slough	31	
	Mission Creek	10	
	Montecito Creek	5	
	Carpinteria Creek	20	
	Rincon Creek	5	
Santa Monica Mountains	Big Sycamore Canyon Creek	10	*17% remaining*
	Arroyo Sequit	10	
	Malibu Creek	34	
	Las Flores Canyon Creek	3	
	Topanga Canyon Creek	30	
Mojave Rim	Los Angeles River	0	*2% remaining*
	San Gabriel River	2	
	Santa Ana River	3	
Santa Catalina Gulf Coast	San Juan River	10	*28% remaining*
	San Mateo Creek	76	
	San Onofre Creek	20	
	Santa Margarita River	41	
	San Luis Rey River	10	
	San Dieguito River	43	
	San Diego River	9	
	Sweetwater River	5	
	Otay River	14	
	Tijuana River	52	

4.2.6 Environmental Variability

Climatic variation has exacerbated the problems associated with degraded and altered riverine and estuarine habitats. For example, periodic drought conditions reduce already limited spawning, rearing and migration habitat in southern California. Productive ocean periods may help to temporarily offset reduced recruitment from degraded freshwater habitat conditions (Busby *et al.* 1996). Although difficult to quantify, the positive or negative effects of environmental variation between years and across longer periods of time can swamp the positive or negative effects of anthropogenic threats. Given this possibility, actions that allow the species to capitalize on positive environmental conditions or withstand negative conditions are critical.

4.2.6.1 Climate Change Effects on Steelhead

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

The weather regime prevailing over a region is not static, but can change either cyclically or directionally over extended periods (Barry, et al. 1998; Bradley, and Jones 1995; Burroughs 2003). The current climate of the SCS Recovery Planning Area is classified as Mediterranean. This climatic regime is characterized by two distinct annual seasons: a long rainless season extending from May through November and a brief rainy season from December through March. Rainfall is associated with brief, but intense, cyclonic winter storms, though the extreme southern portion of the SCS Steelhead Recovery Planning Area is subject to occasional summer storms originating from the Gulf of California. 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 (Changnon, 2000; Intergovernmental Panel on Climate Change 2007; Philander 1990, 2004). 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 (Bailey 1966; Felton 1965).

River discharge, and therefore freshwater habitat conditions, within southern California watersheds is strongly influenced by the intra- and inter-annual pattern of short-duration cyclonic storms (*e.g.,* frequency, timing, and intensity). As a result, river discharge varies 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. Snow accumulation is generally small and of short duration, and does not contribute significantly to peak run-off. Base flows in some river reaches can be influenced significantly by groundwater stored and transported through alluvium, faults, and fractured rock formations. Many rivers and streams naturally exhibit interrupted base flow patterns (alternating channel reaches with perennial and seasonal surface flow) controlled by geologic formations, and the strongly seasonal precipitation pattern characteristic of a Mediterranean climate (Boughton *et al.* 2008; Faber *et al.*, 1989).

The potential effects of projected future climate changes are manifold and complex, varying in range and intensity, across various landscape scales and ecosystem types, and also include human responses to such effects of climate change as sea-level rise, reduced rainfall and runoff, and increase wildfire frequency and intensity. Recent assessments of global climate change and climate change in the United States summarize the general effects on ecosystems (Intergovernmental Panel on Climate Change 2007; Backland *et al.* 2008; Bedsworth and Hanak 2008; and Gutowski, *et al*. 2008; Bedsworth and Hanak 2008; Hanak and Moreno 2008; Barbour and Kueppers 2008; Luers and Mastrandrea 2008; and Hanak and Lund 2008). These 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) which will very likely increase soil erosion; (5) increases in the intensity, frequency and duration of wildland fires; (6) decreased water availability particularly in arid lands, affecting a variety of watershed processes, including run-off, erosion, sedimentation, and a variety of hill-slope process ranging from ravel to mass-wasting and debris flows; (7) increases in water temperatures in rivers and streams that are very likely to have both direct and indirect effects on aquatic systems; (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 in response to changes in precipitation patterns; and (9) changes in the composition, distribution, and abundance of species occupying arid lands due to exceedance of the physiological limits of the native community.

Climate change has the potential to profoundly affect both terrestrial and freshwater ecosystems in California (Bakke 2008; Barbour and Kueppers 2008). There are a number of negative effects on steelhead and their freshwater and estuarine habitats which are of particular significance. These are summarized below:

Rainfall and Runoff. Steelhead depend on adequate rainfall and run-off during their migratory seasons to both enter and emigrate from coastal watersheds. In southern California adequate stream flow is not only necessary for adults to reach upstream spawning areas and juveniles to emigrate to the ocean, but also to breach the sand bar, which seasonally forms at the mouth of most coastal rivers and streams, to allow entrance to and escapement from the watershed.

Rivers and riparian areas (and associated wetland areas) make up less than one percent of the landscape in arid regions such as southern California. These highly productive ecosystems are embedded within upland systems with much lower productivity. The primary driver of terrestrial hydrologic systems is precipitation. Most of the United States experienced increases in precipitation and stream flow and decreases in drought during the second half of the past century. However, there are indications that increases in the severity and duration of droughts have increased in the western and southwestern United States. The full effects of these changes on aquatic organisms such as *O. mykiss* are not well known. However, the introductions of non-native fish and habitat modifications have caused extinctions of numerous endemic species, sub-species, and individual populations of fishes, mollusks, and insects since the late 1800s. The declines in the distribution or abundance of endemic aquatic species has been attributed to a variety of anthropogenic activities coupled with reductions in rainfall and runoff: competitive or predatory interactions with introduced non-native species, livestock grazing, commercial sport fisheries, groundwater pumping, introduced species hybridization, water pollution, recreation and habitat modifications.

Groundwater. Groundwater is an important source of surface flows during dry periods in many Southern California watersheds. Groundwater can therefore contribute to sustaining suitable over-summering juvenile rearing conditions in mainstem and tributary habitats. Surface flows can be maintained as a result of the intersection of a high groundwater table or through transmission water through geologic fault systems. The effects of climate change on groundwater systems has 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 Southern 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 2008). Other Global Climate Models projecting a decrease in vegetative cover would lead to an increase in summer stream flow.

Water Temperature. Increased minimum atmospheric temperatures and warmer spring and summer temperatures have lead to increased stream temperatures in most of the continental Unites States. Increased stream temperatures likely will have both direct and indirect adverse impacts on juvenile *O. mykiss*, by subjecting the species to physiological stress, and altering the aquatic environment through such modifications as reducing dissolved oxygen levels or increased the growth of algae and rooted aquatic vegetation. Elevated stream temperatures can also favor the proliferation of non-native warm water species that can compete for living space, and also prey on native *O. mykiss*, particularly juveniles. Changes in water temperature are most likely to occur during low-flow periods that coincide with over-summering rearing juvenile *O. mykiss*. Stream temperature increases have already begun to be detected across the United States, though no comprehensive analysis similar to streamflow trends has been conducted.

Wildland Fire. Chaparral is the predominant vegetation type within the SCS Recovery Planning Area. Wildfires are a natural phenomenon essential for the periodic renewal of chaparral plant communities (Sugihara *et al.* 2006). In addition, wildfires can have at least temporary major impacts on freshwater habitats of anadromous and non-anadromous *O. mykiss.* These effects range from increasing the erosion, transportation, and deposition of massive amounts of fine sediments in to watercourses containing coarser-grained spawning gravels to destroying riparian

vegetation. The frequency and size of wildfires is expected to increase as a result of increases in atmospheric temperatures.

Santa Ana winds and human-triggered ignitions play an important role in the fire regime of southern California chaparral and scrubland forests. Santa Ana 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 Watershed coupled with low pressure off the coast of southern California, which drives dry air toward the coast. These winds can reach up to 100 km/hr and can spread fires rapidly, sometimes burning 30,000 ha of chaparral and shrub vegetation per day. Using General Global Climate Models, Miller and Schlegel (2006) predict that the total number of annual Santa Ana wind events would not change over the next 30 years, though one of the General Climate Model simulations showed a shift in the seasonal cycle, with fewer Santa Ana wind events occurring in September and more occurring in December. The potential implications of this shift for the fire regime are unclear (Keeley *et al.* 1999).

Sea Level Rise. One of the several life-history strategies exhibited by steelhead is the "lagoon-anadromous" strategy in which juveniles rear a portion of the year in the estuary of their natal river or stream. Studies in small coastal estuaries seasonally closed off from the ocean by sand bars have shown these areas to be productive rearing areas for *O. mykiss*, with juveniles growing fast enough to migrate to the ocean after their first year, and generally at a larger size than juveniles rearing in the freshwater portion of the stream system. Fish that enter the ocean at a larger size exhibit greater survival rates in the ocean, and thus tend to be disproportionately represented in the adult spawning population (Bond 2006).

Current climate trends predict a future of warmer oceans and melting glaciers and icecaps, all of which are expected to raise mean sea levels, leading to the inundation and displacement of many estuaries and lagoons. A rise sea level will most dramatically affect those estuaries which have been confined by surrounding development that prohibits their boundaries from naturally shifting in response to inundation. Projections for sea-level rise by 2100 vary from 0.18 to 0.58 m, to 0.5 to. 1.4 m. (Edgerton 1991; Intergovernmental Panel on Climate Change 2007, Rahmstorf 2007, Raper and Braithwaite 2006). Paleoclimatic data suggest that the rate of future melting of Greenland and Antarctic ice sheets and related sea-level rise could be faster than currently projected (Overpeck *et al*. 2006).

A projected 1m rise in sea level would lead to the potential inundation of 65 percent of the coastal marshlands and estuaries in the continental United States. In addition to the inundation and displacement of estuaries/lagoons, there would be shifts in the quality of the habitats in affected coastal regions. Prior to being inundated, coastal watersheds would become saline due to saltwater intrusion into the surface and groundwater.

4.2.6.2 Marine Environment

Steelhead spend a majority of their life cycle in the marine environment, and only enter freshwater habitats for brief periods to reproduce. 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. Also, steelhead have not been observed in the

marine environment in large aggregating schools with well-defined ocean migratory patterns. The incidental capture of steelhead in the marine environment as a by-catch of commercial fishing activities is uncommon. As a result of the apparent dispersal of single individuals or small groups in the marine environment, information on the movements, feeding habits, and predator-prey relationships of steelhead have not been extensively studied and are not well understood. While steelhead are subjected to the same basic oceanic conditions (*e.g.*, currents, water temperature, up-welling, abundance of prey base, predator-prey interactions, and water quality) as other anadromous Pacific salmon, they may respond and be affected by such conditions differentially because of their unique behavioral, physiological and other ecological characteristics. However, as with other anadromous Pacific salmon, conditions in the marine environment are crucial to the growth, maturation, mortality, and abundance of returning adult steelhead to their freshwater spawning habitats.

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. For some groups of organisms, the northern end of the CCE is dominated by sub-arctic boreal fauna whereas the southern end is dominated by tropical and sub-tropical species. Faunal boundaries (*i.e.*, regions where rapid changes in species composition are observed) are known for the waters between Cape Blanco Oregon/Cape Mendocino California, and in the vicinity of Point Conception California. Higher trophic level organisms often take advantage of the strong seasonal cycles of production in the north by migrating to the region during the summer to feed. Animals which exhibit this behavior include pelagic seabirds such as black-footed albatross and sooty shearwaters, fishes such as Pacific whiting and sardines, and gray and humpback whales. 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. The response of ocean conditions, plankton and fish to these events is well documented in the scientific literature. The biological responses are often so strong that the animals give early warning of events.

Climate-Induced California Current Ecosystem Issues

Numerous climate stressors (*e.g.*, warming, sea level rise, freshwater flow) impact productivity and structure throughout the CCE. It is difficult to isolate the effect of individual stressors on most individual species, and most of these stressors impact many species at multiple trophic levels. Five climate-related issues are of greatest concern in the CCE (National Marine Fisheries Service 2007e). 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 (National Marine Fisheries Service 2007e).

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

One of the likely consequences of global climate change will be a more volatile climate with greater extreme events on the intra-seasonal to inter-annual scales. For the CCE this will mean

more frequent and severe winter storms, with greater wind mixing, higher waves and coastal erosion, and more extreme precipitation events and years, which would impact coastal circulation and stratification. Some global climate models predict a higher frequency of El Niño events; others predict that the intensity of these events will be stronger. If true, primary and secondary production will be greatly reduced in the CCE, with negative effects transmitted up the food chain.

The Pacific Decadal Oscillation (PDO) is a pattern of Pacific climate variability that shifts phases approximately every 20 to 30 years. During a "warm", or "positive", phase, the west Pacific becomes cool and part of the eastern ocean warms and during a "cool" or "negative" phase, the opposite pattern occurs. Most models project roughly the same timing and frequency of decadal variability in the North Pacific under the impacts of global warming. However, combined with the global warming trend, the CCE is likely to experience a greater frequency of years consistent with historical periods of lower productivity (*e.g.,* positive PDO values). We know from ongoing observations that a positive PDO and warmer ocean result in dominance of small warm-water zooplankton (which are lipid-depleted) which may result in food chains with lower bioenergetic content. By about 2030, it is expected that the *minima* in decadal regimes will be *above* the historical mean of the 20th century (*i.e.*, the greenhouse gas warming trend will be as large as natural variability).

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

While variability in ocean conditions has substantial impacts on salmon survival and growth, future changes in freshwater and river conditions will also likely have a great effect on production of anadromous fish. Potential changes in rainfall and snow pack are likely to increase winter and spring runoff but decrease summer runoff. Climate models project the 21st century will feature greater precipitation in the Pacific Northwest, extreme winter precipitation events in California, and a more rapid spring melt leading to a shorter, more intense spring period of river flow and freshwater discharge. This will greatly alter coastal stratification and mixing, riverine plume formation and evolution, and the timing of transport of anadromous populations to and from the ocean.

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

The chief issue for the CCE is the onset and length of the upwelling season: when upwelling begins and ends (*i.e.,* the “spring” and “fall” transitions). The biological transition date provides an estimate of when seasonal cycles of significant plankton and euphausiid production are initiated. At present there is some evidence that coastal upwelling has become stronger over the past several decades due to greater contrasts between warming of the land (resulting in lower atmospheric pressure over the continent) relative to ocean warming. The greater cross-shelf pressure gradient will result in higher alongshore wind speeds and the potential for more upwelling (Bakun, 1990). Regional climate models project that not only will upwelling-favorable winds will be stronger in summer, but that the peak in seasonal upwelling will occur later in the summer (Snyder *et al.* 2003).

Even though northward winds that cause coastal upwelling are likely to increase in magnitude, it

is not known if these winds will be able to over-ride increased water column stratification (see issue 4, below). That is, the winds may not be able to mix this light buoyant water or transport it offshore resulting in the inability of the cold nutrient-rich water to be brought to the sea surface. Thus, phytoplankton blooms may not be as intense, which may impact organisms up the food chain (Roemmich and McGowan, 1995).

Given that the future climate will be warmer, the upper ocean at the Watershed scale will almost certainly be, on average, more stratified. This will make it more difficult for upwelling to mix the upper layers of the coastal ocean, and will make offshore Ekman pumping less effective at bringing nutrients into the photic zone. The result will be lower primary productivity everywhere (with the possible exception of the nearshore coastal upwelling zones).

Should global warming result in shorter winters in the north Pacific, areas where production is light limited may see higher productivity, in the northern California Current for example. That is, we know that phytoplankton blooms are initiated as early as February in the northern California in years when storm intensity is low, and this has been the case in most years since 2002. These early blooms result in bursts in egg production by both copepods and euphausiids, thus initiating a cohort of animals that will reach adulthood one-two months earlier than a cohort that is initiated with the onset of upwelling in March or April. The result would be a longer plankton production season. Alternatively, regional climate projections are for a later shift in the start time, peak times and end of the upwelling season, which could counter the idea of a longer upwelling season.

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

This issue focuses on the central and southern California Current, and on the organisms that utilize the upper ocean habitat in this region. Generally warmer ocean conditions will cause a northward shift in the distribution of most 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. Warmer water temperatures will also affect freshwater salmon habitats, by reducing habitat opportunity on both spatial and seasonal time scales. In coastal and oceanic regions, the southern boundaries of the pelagic habitat of many populations will likely shift northward.

Warmer air temperatures may lead to increased stratification of the coastal CCE. The warmer temperatures will increase the heat flux into the ocean. Mixing and diffusion are not likely to redistribute this heat rapidly enough to prevent an increase in thermal stability and stratification of the upper ocean. 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. Moreover, increased melting of glaciers in the Gulf of Alaska coupled with warmer sea surface temperatures will result in increased stratification of the Gulf. Since some of the source waters that supply the northern California Current originate in the Gulf of Alaska, more stratified source waters will contribute to increased stratification of coastal waters of the northern California Current.

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

The California Current begins at the northern tip of Vancouver Island Canada, and ends somewhere between Punta Eugenia and the tip of Baja California Mexico. The alongshore extent is on the order of 28° of latitude (51°N to 23°N). As the current flows from north to south, the waters warm and mix with offshore waters such that both temperature and salinity increase gradually in a southward direction. Not surprisingly, observations of the biota of the California Current show that there are pronounced latitudinal differences in the species composition of plankton, fish, and benthic communities, ranging from cold water boreal sub-arctic species in the north to warm water subtropical species in the south. Changes in abundance and species composition can be gradual in some cases, but it is widely accepted that faunal boundaries (zones of rapid change in species composition) are present in the waters in the vicinity of Capes Blanco and Mendocino, and at Point Conception. The strongest contrasts are seen during summer.

The strong contrast in species composition between shelf and offshore waters during summer is due to the upwelling process. A combination of upwelling itself along with the sub-arctic water which feeds the inshore arm of the northern end of the CCE create conditions favorable for development of a huge biomass of sub-arctic zooplankton. This pattern is slightly modified as a function of the phase of the PDO. During cool phase, all of the northern CCE becomes more sub-Arctic in character (both shelf-slope-oceanic regions); during warm phase of the PDO, the water masses and associated copepod community becomes far more similar to a sub-tropical community. Copepod biodiversity increases in coastal waters, due to shoreward movement of offshore waters onto the continental shelf, due to either weakening of southward wind stress in summer or strengthening of northward wind stress in winter. Thus, when PDO is in positive phase, a greater proportion of the water entering the northern end of the current is sub-tropical in character rather than sub-Arctic.

Regardless of the season, the source waters that feed into the California Current from the north and from offshore can exert some control the over the phytoplankton and zooplankton species that dominate the current. Hooff and Peterson (2006) suggest that knowledge of source waters is critical to understanding ecosystem dynamics in the shelf waters of the Northern CCE because waters from the Gulf of Alaska carry large, lipid-rich copepods to the shelf waters, whereas waters coming from an offshore source carry small, oceanic lipid-poor copepods to the shelf waters. Thus PDO changes may result in local food chains that have vastly different bioenergetic content. Given for example that (a) salmon returns are low when the PDO is in a positive, warm-water phase, but high when the PDO is in a negative, cold-water phase, (b) salmon returns to Pacific Northwest rivers are highly correlated with copepod community structure (Peterson and Schwing 2003, Peterson et al., 2006) we suggest that variations in the bio-energetic content of the food web represent a mechanistic link between PDO sign change and salmon survival.

Northward shifts in distribution are also possible. Generally warmer conditions could result in a northward shift in the distribution of some species, and possibly the creation of reproductive populations in new regions. Examples include Pacific whiting which migrate far to the north, to Canada, during warm summers. Moreover, there is evidence that both hake and sardines are now spawning in waters off Oregon and Washington (R. Emmett, personal communication, Northwest Fisheries Science Center).

Alternatively, if upwelling strengthens due to global climate change, regardless of the sign of the PDO, cold-water species should still be favored in the coastal upwelling zones. However, the onshore-offshore gradients in temperature and species abundance should strengthen if offshore waters become warmer and upwelling becomes stronger, creating stronger upwelling fronts, and perhaps a greater level of mesoscale activity. It is unclear how faunal boundaries might be affected.

5. 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."

Interim Endangered and Threatened Species Recovery Planning Guidance, National Marine Fisheries Service, 2007

5.1 DPS RECOVERY GOAL

Our goal is *to prevent the extinction of southern California steelhead in the wild and ensure the long-term persistence of viable, self-sustaining, harvestable, interacting wild populations of steelhead distributed across the DPS*. Recovery of this DPS will require reducing threats to the long-term persistence of multiple populations that are geographically dispersed among the diverse habitats of the species' range, preserving the diversity of steelhead life-history strategies and adaptations (*e.g.* switching between resident and anadromous forms, emigration age, timing and frequency of anadromous runs, dispersal rates between watersheds, and local habitat adaptations).

Recovery of the DPS will require the protection, restoration, and maintenance of habitats of sufficient quantity, quality, and natural complexity throughout the DPS so that the full range of all life-history forms of *O. mykiss* are able to successfully use as many types of habitat as possible, in as many ways as possible, in order to overcome the natural challenges of a highly variable natural environment and random or unpredictable biological processes.

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).

5.2 DPS RECOVERY OBJECTIVES

To ensure recovery of the DPS, specific recovery 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 ensure the recovery goal is met.

Steelhead in southern California occupy a wide array of watersheds, some portions of which are severely disturbed with highly modified natural watershed processes and streamflows. Under these degraded habitat conditions, steelhead populations in some watersheds have declined to very low numbers where they continue to persist. In other watersheds, populations have been extirpated, particularly at the southern end of the species' range. Existing threats constrain the species current distribution to small portions of its historic range and preclude the species from expressing its full range of life-history strategies to respond to varying habitat conditions. In order to recover, the species needs substantially higher numbers of returning adults, successful spawning and rearing in freshwater and estuarine environments, and successful migration of juveniles to the ocean. To achieve these goals, it is critically important to preserve and restore the species' existing habitat, as well as restore its access to historically important spawning and rearing habitats. 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, variable ocean-rearing conditions, wildfires, and long-term climate changes.

To recover steelhead, the following objectives have been identified:

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

5.3 RECOVERY CRITERIA

Prior to determinations that 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, related to the condition of the species and the status of the threats to the species, must be met. In the case of delisting the Southern California Steelhead DPS, biological recovery criteria regarding the

abundance, productivity, spatial structure, and diversity of the populations within the DPS and the DPS as a whole, are the measures of recovery. Threats abatement criteria are indicators that key threats to the populations and DPS have been abated or controlled. Both types of recovery criteria will be used by NMFS to assess whether the species is recovering (moving towards meeting the criteria, and down listing may be appropriate) or has recovered (meets the criteria and delisting may be appropriate). Several of the criteria are not yet measurable or quantitative because additional research is needed to define or refine them. For this reason one of the five recovery objectives focuses on the research and monitoring needed to refine the criteria and directly measure whether steelhead populations are meeting the criteria. In addition, NMFS has proposed down listing criteria that would mark the transition between endangered and threatened status for the Southern California Steelhead DPS, but further information is needed for refinement of these criteria as well. Given the species' condition and the severity of the threats to the species, significant increases in population and DPS health and reductions in critical threat sources are needed before the species' risk of extinction shifts from imminent to the "foreseeable future." In the meantime, strategies and actions needed to move the species towards a threatened status are the same as those needed for recovery.

5.3.1 Biological Recovery Criteria

The TRT developed general viability criteria for both individual steelhead populations and for the DPS as a whole. These criteria describe characteristics of both individual populations and the DPS that if achieved would indicate that the DPS is viable, and therefore at a low risk of extinction over a specific period of time (for a detailed discussion of the methods used by the TRT to develop the recommended viability criteria, please see Boughton *et al.* 2007). The population and DPS criteria are independent of anthropogenic effects in the sense that they must be met regardless of habitat conditions and human-caused threats. The time frame and related recommended criteria address the preservation of the evolutionary potential of the species (*i.e.*, existing genetic, phenotypic, and behavioral diversity) by ensuring that the DPS will persist over a long enough period of time to exhibit future evolutionary changes such as adaptation or diversification in response to environmental changes. Preserving the evolutionary potential of the species is an important component in ensuring the species' long-term viability.

The viability criteria recommended by the TRT provide guidance for judging recovery of steelhead populations and the DPS given our current level of knowledge. All of the recommended criteria carry varying levels of uncertainty depending on the amount of information available on steelhead in the SCS Recovery Planning Area. Given the high levels of scientific uncertainty, NMFS proposes to adopt many of the viability criteria as recovery criteria until such time as sufficient scientific information is available to refine the criteria for assessing population and DPS viability.

Table 5-1 summarizes the recovery criteria proposed for the Southern California Steelhead DPS. The population level criteria apply to certain populations in all of the BPGs (see Chapter 2 and Table 2-2, "Steelhead Biology and Ecology", and Chapter 6 "Recovery Strategy" for a discussion of these populations). Further research is needed to refine the population specific criteria in all BPGs, as well as the role of each of the BPGs in the recovery of the DPS. At a minimum, all BPGs

Table 5-1. Biological Recovery Criteria for the Southern California Steelhead DPS

POPULATION-LEVEL CRITERIA – Apply to Populations selected to meet DPS-level criterion D.1.1		
Criterion Type	**Recovery Threshold**	**Notes**
P.1 Mean Annual Run Size	Run size is sufficient to result in an extinction risk of <5% within 100 yrs	Monitoring run size will provide information on year-to year fluctuations in the population necessary to determining the appropriate recovery threshold for individual populations. Research on the role of non-anadromous spawning fraction in stabilizing anadromous faction will also enable refinement of the minimum recovery threshold (see Boughton *et al.* [2007] for discussion of steps in determination of threshold value for each viable population).
P.2 Ocean Conditions	Run Size criterion met during poor ocean conditions	"Poor ocean conditions" determined empirically, or size criterion met for at least 6 decades
P.3 Spawner Density	*Unknown at present*	Research needed
P.4 Anadromous Fraction	N = 100% of Mean Annual Run Size	Requires further research
DPS-LEVEL CRITERIA		
Criterion Type	**Recovery Threshold**	
D.1 Biogeographic Diversity	1. Biogeographic Population Group contains minimum number of viable populations: Monte Arido Highlands (4 populations); Conception Coast (3 populations); Mojave Rim (3 populations); Santa Monica Mountains (3 populations); Santa Catalina Gulf Coast (8 populations) (see Boughton *et al*. 2007 for detailed discussion) 2. Viable populations inhabit watersheds with drought refugia 3. Viable populations separated from one another by at least 68 km or as widely dispersed as possible	
D.2 Life-History Diversity	Viable populations exhibit all three life-history types (fluvial-anadromous, lagoon-anadromous, freshwater resident)	

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.

will need to achieve sufficient spatial structure and diversity (*i.e.,* two of the four criteria that define a viable DPS in the wild). Dispersal of steelhead between BPGs may be an important mechanism for maintaining viability of steelhead populations. In addition, preservation of the resident form of the species and habitats that support that life-history form may be critical to conserving the genetic diversity of steelhead and provide stock that can re-establish and support the fluvial-anadromous and lagoon-anadromous life-history strategies.

5.3.1.1 Discussion of Population-Level Recovery Criteria

Criterion P.1 – Mean Annual Run Size. There is substantial uncertainty regarding the mean annual run size that would represent viable anadromous *O. mykiss* populations throughout the DPS. The TRT estimated a mean annual run size for the DPS using a robust method and quantitative field data for one anadromous *O. mykiss* population and 19 Chinook salmon populations in California's Central Valley. The resulting criterion of 4,150 spawners per year provides for a 95 percent chance of persistence of the population over 100 years and applies to a generalized situation where there are no quantitative field data on specific local populations. Based on the irregular inter-annual patterns of precipitation, anecdotal accounts of highly variable spawning runs and the expectation that larger abundances buffer populations against the increased extinction risks that come with variations in freshwater and marine survival, it can be expected that an average of 4,150 spawners per year, and persisting through a cycle of poor ocean conditions would be adequate to safeguard a population (See also discussion below of P.2 – Ocean Conditions). This target may be biologically feasible in larger watersheds within the SCS Recovery Planning Area (for example, rivers within the Monte Arido Highlands), but may be too high for some relatively small populations that may be viable at average run sizes well below 4,150 (*e.g.,* because of reliable access to spawning and rearing areas, a stable freshwater environment, the role of non-anadromous forms of *O. mykiss*, inter-watershed exchanges of anadromous forms of *O. mykiss*, or other factors).

The separate watersheds comprising each BPG are treated as individual steelhead populations for the purposes of meeting the run-size criterion. Because of uncertainty regarding the applicability of 4,150 spawners per year to many of the watersheds within the DPS and the lack of current data to develop more refined criteria, this recovery plan proposes that performance-based run-size criteria be developed for different core populations throughout the DPS. Development of this criterion for each population would utilize a precautionary approach towards determining run sizes that provide for a 95 percent chance of persistence of the population over 100 years. In general, the 4,150 number can be thought of as an approximate upper bound 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*. 2007).

Methods exist for estimating extinction risk through the use of time-series of spawner counts (Holmes 2001, Lindley 2003, Dennis *et al*. 2006). In general, about 20 years of data are necessary to obtain reasonable confidence in such estimates (Lindley 2003), though recovery to some level is necessary in many watersheds in order to have a sufficient number of spawners to refine performance-based criterion. The performance criterion development approach requires that we learn about some key risk factors before settling on final viability targets, including: 1) the magnitude of year-to-year fluctuations in spawner abundance; 2) the magnitude and duration of

poor ocean survival during poor ocean conditions; and 3) the ability or inability of rainbow trout to contribute progeny to steelhead populations and thereby bolster steelhead populations during periods of otherwise poor survival. Obviously, these factors and the years of data collection required highlight the critical need for immediate implementation of population abundance monitoring in key watersheds. However, some populations may currently have run sizes so low that obtaining accurate counts would be difficult because of the small sample size, or surveying may be detrimental because of the associated mortality associated with sampling techniques. Collecting useful data may not be practical until such populations have been recovered to some level, depending on the field methods used for monitoring. Boughton *et al.* (2007) describe a decision tree for use in refining and establishing a viability criterion for mean population size.

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

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

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

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

As performance-based run-size criteria are developed for populations within this DPS, the methods and data used to develop those values may change the ocean conditions criterion or even preclude the need for such a specific criterion. 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 has benefits and risks to the viability of the population. If too thinly spread-out, populations can decline as a result of the difficulty of locating mates, but may also reduce their vulnerability to localized catastrophes or environmental variations by occupying a broader range of habitats. If too densely packed, populations may be more vulnerable to unpredictable environmental events as all the members of the population experience the same conditions. The TRT felt that a viability criterion related to the density of spawners in a population is warranted, particularly for populations that were historically large, but are unlikely to be recovered to those historic levels due to a risk that a thinly dispersed population in such a watershed could meet the criterion for mean size, and yet not be viable. The TRT also believes that the viability threshold should be high enough to ensure that fish generally inhabit good-quality habitats that promote the resilience of the population. A potentially suitable threshold for both these purposes is the density at which intra-specific competition for redd sites becomes observable. For coho salmon (*O. kisutch*) this appears to be on average about 40 spawners per kilometer (one spawning pair per 50 meters of stream length), although individual streams vary considerably around this mean (Bradford *et al*. 2000). However, the TRT could not find data for deriving a corresponding steelhead criterion. The Coastal Monitoring Plan proposed to implement redd-counting for monitoring salmon and steelhead in the northern coastal area of California (Aptos Creek to the Oregon border). This should provide data that will be useful for deriving a specific spawner density criterion; also redd-counts could be made in the southern Life-Cycle Monitoring Stations if it is necessary for developing specific southern California criterion.

Criterion P.4 – Anadromous Fraction. Anadromous fraction is the mean fraction of reproductive adults that are anadromous (steelhead). Steelhead in the Southern California DPS co-occur with rainbow trout. Elsewhere, steelhead have been observed to have trout among their progeny, and vice versa (Zimmerman and Reeves 2000). We do not know how often these transitions occur in southern California, or what factors bring them about, though clearly individual populations can have more than one life-history type. 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—the existence of a "rescue effect" and the possibility of recolonization (Hanski and Gilpin 1997). The rescue effect would occur at low steelhead abundance, when input from the trout population prevents their complete disappearance. Recolonization occurs when steelhead disappear completely, but are regenerated by the trout population (via "recolonization" of the steelhead niche). These phenomena may have maintained steelhead in the Santa Clara River system in recent times, since modern steelhead runs appear far too small to be self-sustaining (Boughton 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 criterion for anadromous fraction must assume that the rescue effect is negligible, and that anadromous fraction must be 100%—that is, when applying the population size criterion discussed previously, 100% of the spawners must be anadromous. Future research on this topic could be used to estimate a viability threshold that is more efficient than the precautionary "100% rule." One of the most useful scientific tools for addressing the interchange question involves otolith microchemistry; because 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. 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 empirical research.

5.3.1.2 DPS-Level Recovery Criteria

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

Recovery of this DPS will require recovery of a sufficient number of viable populations (or sets of interacting trans-watershed populations) within each of the five 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. Also essential to the recovery and long-term conservation of this DPS is the preservation and restoration of all the life-history forms and strategies the species has evolved to exploit the diversity and range of habitat conditions that are characteristic of southern California. These life-history forms include the fluvial-anadromous, lagoon-anadromous, and freshwater life-history patterns exhibited by native *O. mykiss* throughout the DPS. Achieving this goal will require a number of closely coordinated activities, such as further research into the diverse life-history patterns and adaptations of steelhead to a semi-arid and highly dynamic environment including the ecological relationship between non-anadromous and anadromous populations; monitoring of existing populations; and the implementation of the recovery plan. The two most important families of research questions for management purposes are: 1) which ecological conditions favor particular life-history forms; and 2) what ecological conditions promote and prompt plasticity in life-history trajectories, and to what extent does such plasticity stabilize the anadromous DPS? Answers to the first question would allow focusing on management activities (*e.g.,* removal of physical or hydrologic migration barriers,) to produce the suite of conditions that promote the coexistence of the different life-history forms; answers to the second would help refine the viability criteria P.1 (Mean Annual Run Size), P.4

(Anadromous Fraction), and D.2 (Life-History Diversity). Regarding the last criterion, it research may indicate that not all life-history forms may have to be present in all viable populations on a regular basis, but only periodically.

5.4 THREATS ABATEMENT CRITERIA

The current threat regime that is impeding the ability of anadromous *O. mykiss* to recover must be addressed to meet the population and DPS-level recovery criteria described above. In addition, our efforts to reduce the threats facing the species must also take into consideration future threats to species recovery such as climate change, ongoing human population growth, and associated land and water developments. Here we define basic threats abatement criteria for use in measuring the success of recovery efforts. The identified existing and future threats (see sections 8.4 – 12.4 for each BPG) fall within the categories of listing factors identified during the species listing process. Each of these factors must be addressed prior to making a determination that a species has recovered and no longer requires the protections of the ESA.

This plan prioritizes recovery actions for the watersheds within the BPGs according to the role of the watershed in recovery of the species, the severity of the threat addressed by the action, and the listing factors addressed by the action. Each recovery action has been given a priority of 1, 2, or 3 as defined in the NMFS Interim Recovery Planning Guidance (see box, below, for definitions) and 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. Where the recovery action addresses both types of listing factors, the descriptor is based on the principal listing factor addressed. Priority 1 actions are aimed to prevent the DPS as a whole, though they may be implemented on individual populations that are critical to prevent the extinction of the DPS. Priority 2 actions are intended to avoid prejudicing the recovery of the DPS as a whole by ensuring that populations essential to recovery are not further degraded or lost, thus precluding the full recovery of the DPS. Priority 3 actions are the full suite of actions necessary to meet all the viability criteria identified for the full recovery of the DPS (including individual populations).

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.

Priority 3: All other actions necessary to provide for full recovery of the species.

As a basic threats abatement criterion, NMFS proposes that all watershed threats having a priority 1 recovery action 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 analysis methodology used in the threats assessment (*e.g*. abate from "high" to "medium," or "medium" to "low").

An example of the application of these threats abatement criteria can be seen in Table 5-2. In this example, high-level (red) threats associated with high-priority (1A and 1B) recovery actions must be 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 5-2. Example application of basic threats abatement criteria

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

These basic threats abatement criteria are supplemented by additional criteria that are specific to particular conditions NMFS believes are critical to meet the recovery goal for the species. The criteria are linked to one or more of the listing factors identified for the Southern California steelhead DPS. Only Listing Factor B, Over-utilization, does not have a specific threat abatement criteria identified as changes in fishing regulations have already ameliorated the threat posed to the species from angling. These threat abatement criteria are that:

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

5.5 PROVISIONAL RECLASSIFICATION CRITERIA

5.5.1 Reclassification of an Endangered Species.

When a species is listed as endangered, it is appropriate to identify intermediate recovery criteria which if achieved would allow for the reclassification (or down listing) of the species from endangered to threatened. A threatened species is defined in the ESA as "any species which is likely to become endangered species within the foreseeable future throughout all or a significant portion of its range" but is not currently in danger of extinction (Sec 3 [19]).

The determination regarding reclassification must be made by the Secretary of Commerce based on any one or a combination of the following factors which are also used for listing a species under the ESA:

1. the present or threatened destruction, modification, or curtailment of its habitat or range;
2. over utilization for commercial recreational, scientific or educational purposes;
3. disease or predation;
4. the inadequacy of existing regulatory mechanisms; or
5. other natural or manmade factors affecting its continued existence.

The reclassification of a species from endangered to threatened, as with the initial listing, must be based on the best scientific and commercial data available, without reference to possible economic or other impacts, after conducting a status review of the species. The ESA provides for a process for regularly assessing the status of a listed species through the completion of periodic review of the species that are listed as threatened or endangered to ensure that the listing status of a species remains current. Specifically, Section 4(c) (2) of the ESA provides that:

> "The Secretary shall –
>
> (A) conduct , at lest one every five years a review of all species included in a list . . . and which is in effect at the time of such review; and
>
> (B) determine on the basis of such review whether any such species should-
>
> (i) be removed from such list;
>
> (ii) be changed in status from an endangered species to threatened species; or
>
> (iii) be changed in status for a threatened species to an endangered species."

Evaluating the status of a species for potential reclassification requires an explicit analysis of the threats specified under the five listing factors, in addition to an evaluation of the population or other demographic parameters of the listed species (e.g., anadromous fraction, life-history types, etc.) Status reviews of a species periodically conducted by NMFS may serve as a 5-year review for the purposes of reclassification.

As with recovery criteria, reclassification criteria address both the status of the species (biological criteria) and the status of the threats to the species (threats abatement criteria). The biological criteria deal with the abundance, spatial distribution, and diversity of the populations within the

DPS, and the DPS as a whole. The threats abatement criteria are indicators that the key threats to the population and the DPS as a whole have been abated or controlled.

Because of the uncertainty regarding key recovery criteria (*e.g.*, annual run size) reclassification criteria must necessarily be both provisional and precautionary (see discussion regarding recovery criteria in sections 5.3.1.1 5.3.1.2). Further, reclassification criteria must ensure that the full recovery of the species is not prejudiced or precluded by failing to address the fundamental threats to the species, including, but not limited to its natural spatial distribution and diversity. The reclassification criteria identified below, if met, are intended to achieve partial recovery of the species, and ultimately contribute to the full recovery and delisting of the speic1es. These criteria constitute a sub-set of the recovery criteria and address the most significant threats in the highest priority watersheds in each of the five BPGs with in the DPS. Full recovery will require addressing the full set of recovery criteria, including lower priority threats in the full suite of watersheds which would constitute a recovered DPS.

5.5.1 Population Level Reclassification Criteria

The following reclassification criteria must be met for the specified number of populations in each of the five BPGs (listed below) to down-list the species from endangered to threatened:

- *Population Reclassification Criterion PR 1: Mean Annual Run Size* – Run size is sufficient to result in an extinction risk of <5% within 50 years (not including poor ocean conditions).

- *Population Reclassification Criterion PR 2: Anadromous Fraction* – N= 100% of Mean Annual Run Size.

5.5.2 DPS-Level Reclassification Criteria

The following reclassification criteria must be met for the DPS to down-list the species from endangered to threatened:

- DPS Biogeographic Diversity Criteria DR 1: Meet the population level reclassification criteria for the specified number of populations in each of the five BPGs:

Monte Arido Highlands BPG:	2 Core 1 Populations
Conception Coast BPG:	2 Core 1 Populations
Santa Monica Mountains BPG:	1 Core 1 Population
Mojave Rim BPG:	1 Core 1 Population
Catalina Gulf Coast BPG:	2 Core 1 Populations

5.5.3 Reclassification Threats Abatement Criteria

In order to meet the above population and DPS level reclassification criteria the current threat regime that is impeding the ability of anadromous *O. mykiss* to recover must be addressed. The threats analysis conducted for the endangered southern California steelhead has prioritized recovery actions in each BPG (See Table 6-2). Priority 1 recovery actions are defined as those actions that must be taken to prevent the extinction of the species, or to prevent the species from

declining irreversibly, thus precluding the recovery of the species. To meet the reclassification threat abatement criteria the threat levels identified as high priority threats in the Core 1 populations must be reduced to medium or low, which ever is necessary to meet the population level reclassification criteria.

As noted above these reclassification criteria are provisional and precautionary, and before reclassification can occur, the status of the species must be evaluated, either through a five-year review or a separate status review pursuant to the requirements of the ESA and applicable administrative regulations.

6. Steelhead Recovery Strategy

"The aim of the Federal Endangered 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 and has two components: a technical part and a policy part."

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

For millennia southern California steelhead have successfully dealt with natural environmental fluctuations such as prolonged droughts, flash-floods, uncontrolled wildfires, sea-level alternations, periodic massive influxes of sedimentation, and climate changes—natural environmental fluctuations which also currently challenge the human population of southern California.

Of the approximately 37 million people currently living in California, approximately 23 million live in the southern California counties of Santa Barbara, Ventura, Los Angeles, Orange, Riverside, San Bernardino, and San Diego. As a result of this extensive human population, and related development, steelhead populations, along with many other indigenous species of both animals and plants, have been severely reduced or extirpated in many coastal watersheds. Despite extensive landscape modifications, steelhead have continued to persist, in one or more of its several life-history forms, in portions of many southern California watersheds, including some of the most highly urbanized.

Recovery of viable, self-sustaining populations of anadromous southern California steelhead will entail the re-integration of these populations into the human configured landscape. Such re-integration will necessarily entail an effort to restore habitats and operate the human built system in ways which conserves and better utilizes land and water resources in mutually beneficial ways—for southern California steelhead and the current and projected human population. Addressing these challenges therefore provides an opportunity to meet a wide variety of public policy objectives to ensure a sustainable future for the endangered southern California steelhead, as well as other native riparian species, including a number of other federally listed species such as California red-legged frog, Southwestern willow flycatcher, Least Bell's vireo, Arroyo toad, Tidewater goby and Western snowy plover, and the human population occupying the southern California landscape.

Under present conditions, the viability of individual populations is more likely achievable by focusing recovery efforts on larger watersheds capable of sustaining larger populations, and DPS

viability is more likely to be achievable by focusing on the most widely-dispersed set of such core populations capable of maintaining dispersal connectivity between southern California coastal watersheds.

The recovery strategy is the approach undertaken to attain the individual recovery criteria and objectives and, in turn, the ultimate recovery goal of de-listing the Southern California Steelhead DPS. The recovery strategy set forth in this recovery plan identifies the foundation watersheds where recovery of viable populations is necessary to achieve the recovery goal and critical watershed-specific actions (*e.g.*, removal of migration barriers and protection and restoration of spawning and rearing habitats) that are necessary for reversing the effects of past and ongoing threats to population abundance, growth rate, diversity, and spatial structure of endangered steelhead. An integral element in the recovery strategy is the development and implementation of a research and monitoring program which will provide the additional information necessary to refine recovery criteria and objectives, as well as assess the effectiveness of recovery actions and the overall success of the recovery program.

Effective implementation of recovery actions will require: (1) extensive public education (including the general public, non-governmental agencies, and local, regional, State, and Federal governmental agencies) regarding the role and value of the species within the larger watershed environment; (2) development of cooperative relationships with private land owners, special districts, and local governments with direct control and responsibilities over non-federal land-use practices; (3) participation in the land use and water planning and regulatory processes of local, regional, State, and Federal agencies; (4) close cooperation with other state resource agencies such as the California Department of Fish and Game, California Coastal Commission, CalTrans, and the California Department of Parks and Recreation; 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, and the U.S. Environmental Protection Agency.

An implementation schedule describing time frames and costs associated with individual recovery actions is under development. Estimating total cost to recovery is much more challenging, if not impossible to estimate for a variety of reasons. These reasons include the large geographic extent of the SCS Recovery Planning Area; the need to refine recovery criteria; the need to complete watershed-specific investigations such as barrier inventories and assessments; the establishment of flow regimes for individual watersheds; and the review and possible modification of a variety of exiting land-use and water management plans (including waste discharge requirements) under a variety of local, state, and federal jurisdictions. Additionally, the biological response of many of the recovery actions is uncertain, and achieving full recovery will be a long-term effort likely requiring decades, while addressing new stressors that emerge over time. In some instances, however, NMFS is able to estimate the costs associated with certain common restoration activities such as those undertaken as part of the California Department of Fish and Game Fisheries Restoration Grants Program. Appendix E of this document contains estimates for these categories of typical watershed restoration actions.

6.1 CORE POPULATIONS

The findings of the TRT (*e.g.,* Boughton *et al*. 2006) and NMFS' own investigations indicate certain key watersheds and the steelhead populations within those watersheds that form the foundation of the recovery of the Southern California Steelhead DPS (Table 4-4). These watersheds exhibit the physical and hydrological characteristics (*e.g.,* large spatial area, perennial and reliable winter streamflow, stream network extending inland) that are most likely to sustain independently viable populations, and that are critical for ensuring viability of the DPS as a whole. Population viability is more likely achievable by focusing recovery efforts on larger watersheds in each Biogeographic Population Group capable of sustaining larger populations, and DPS viability is more likely achievable by focusing on the most widely-dispersed set of such core populations capable of maintaining dispersal connectivity (see Boughton *et al.* 2006).

In table 6-1 populations are identified as Core 1, Core 2, or Core 3. The Core 1 populations are those populations identified as a high priority for recovery actions based on a variety of factors, including: the intrinsic potential of the population in an unimpaired condition; the role of the population in meeting the spatial and/or redundancy viability criteria; the conditions of the population, 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 1 populations form the nucleus of the recovery strategy and must meet the population-level biological recovery criteria set out in Table 5-1. NMFS believes that this set of Core 1 populations should be the first focus of an overall recovery effort. Core 2 populations also form part of the recovery strategy by contributing 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 eventually meet the biological recovery criteria for populations set out in Table 5-1; however, these populations are of secondary importance in terms of recommended priority of recovery efforts. Finally, the complete attainment of DPS-level biological recovery criteria may also require recovery or stabilization of populations listed as Core 3. For example, further research is needed to refine certain recovery criteria such as the redundancy and separation of populations required to withstand wildland fires. Dispersal connectivity between populations and genetic diversity may be enhanced by working to recover smaller Core 3 populations that serve as stepping stones for dispersal.

Populations identified as being Core 1 and 2 populations would be expected to meet the population recovery criteria either as a single population or a group of interacting trans-watershed populations such as those that might exist in the Conception Coast and more southerly BPGs (Santa Monica Mountains and Santa Catalina Gulf Coast). Further research is needed to identify these interacting groups. In the interim, the population-level recovery criteria are proposed to apply to each core population.

Table 6-1. Preliminary designation of Core 1, 2, and 3 *O. mykiss* populations within the Southern California Steelhead DPS.

BPG	POPULATION	FOCUS FOR RECOVERY
Monte Arido Highlands	**Santa Maria River**	**Core 1**
	Santa Ynez River	**Core 1**
	Ventura River	**Core 1**
	Santa Clara River	**Core 1**
Conception Coast*	Jalama Creek	Core 3
	Canada de Santa Anita	Core 3
	Canada de la Gaviota	**Core 2**
	Agua Caliente	Core 3
	Canada San Onofre	Core 3
	Arroyo Hondo	Core 3
	Arroyo Quemado	Core 3
	Tajiguas Creek	Core 3
	Canada del Refugio	Core 3
	Canada del Venadito	Core 3
	Canada del Corral	Core 3
	Canada del Capitan	Core 3
	Gato Canyon	Core 3
	Dos Pueblos Canyon	Core 3
	Eagle Canyon	Core 3
	Tecolote Canyon	Core 3
	Bell Canyon	Core 3
	Goleta Slough Complex	**Core 2**
	Arroyo Burro	Core 3
	Mission Creek	**Core 1**
	Montecito Creek	Core 3
	Oak Creek	Core 3
	San Ysidro Creek	Core 3
	Romero Creek	Core 3
	Arroyo Paredon	Core 3
	Carpinteria Salt Marsh Complex	Core 3
	Carpinteria Creek	**Core 1**
	Rincon Creek	**Core 1**

Table 6-1 cont'd. Preliminary designation of Core 1, 2, and 3 *O. mykiss* populations within the Southern California Steelhead DPS.

Santa Monica Mountains	Big Sycamore Canyon	Core 3
	Arroyo Sequit	**Core 2**
	Malibu Creek	**Core 1**
	Topanga Canyon	**Core 2**
	Solstice Creek	Core 3
Mojave Rim	Los Angeles River	Core 3
	San Gabriel River	**Core 1**
	Santa Ana River	**Core 2**
Santa Catalina Gulf Coast	**San Juan Creek**	**Core 1**
	San Mateo Creek	**Core 2**
	San Onofre Creek	Core 3
	Santa Margarita River	Core 2
	San Luis Rey River	**Core 1**
	San Diego River	Core 3
	Sweetwater River	Core 3
	Otay River	Core 3
	Tijuana River	Core 3

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

*** Note: these BPGs may not have had consistent anadromy, which complicates the designation of populations that need to achieve viability.*

Public and private groups should not be dissuaded from undertaking actions that alleviate threats to the species in Core 3 watersheds, though the success of restoring Core 3 watersheds is likely contingent on the success in restoring nearby Core 1 and Core 2 populations. While sufficient information regarding threats and the biology and ecology of the species is available to define an overall recovery strategy, there still remain questions regarding the ecology of the species (*e.g.*, function of certain habitats in the life history of the species, relationship between the anadromous and resident forms, rate of dispersal between watersheds). In light of this uncertainty, a prudent approach is to define a recovery strategy based on the existing information on Core 1 and 2 watersheds while recovery opportunities in Core 3 watersheds continue to be actively pursued as a precaution to reduce the risk of extinction. Therefore, while the Core 1 and 2 watersheds form the foundation for recovery of the Southern California Steelhead DPS, recovery actions to alleviate threats should be undertaken in other watersheds to complement this recovery implementation strategy.

6.2 CRITICAL RECOVERY ACTIONS

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

Critical recovery actions should have the highest priority across the DPS and within core watersheds to achieve recovery objectives and criteria. In the tables describing recommended recovery actions for populations within the DPS, these actions have received a priority ranking of 1. Opportunistically, other recovery actions may be implemented prior to these actions, but NMFS considers these critical actions to be the keystones for population recovery or measurement of recovery; such actions are also 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, Aspen Institute 2002; Boughton, *et al.* 2005; Graf, *et al*. 2002, 2003; Hayes, *et al.* 2008; Moyle, *et al.* 2008; Stanley and Doyle 2003.

Although a wide range of anthropogenic activities have contributed to the high extinction risk of the Southern California Steelhead DPS, two types of developments and activities pose the principal threats to the species: (1) impassable barriers, and (2) water storage and withdrawal, including groundwater extraction (see Table 4-1 in Chapter 4). These threats affect basic life-history phases of the species (egg-to-smolt survival and smolt-to-spawner survival) throughout the DPS and are key components of the risks posed to the species. Accordingly, this recovery strategy places a high priority on recovery actions that alleviate threats related to impassable barriers and water storage and withdrawal. Closely related to providing access to rearing habitats is the need to ensure that the ecological functions of those habitats are protected and, where impaired, are restored. The critical recovery actions to address these two threats within the Core 1 watersheds are listed below in Table 6-2.

With regard to effects of impassable barriers on endangered steelhead, the recovery objectives include restoring steelhead distribution to previously occupied areas and restoring genetic diversity and natural interchange within populations and metapopulations. One of the threats abatement criteria identified to meet these objectives is to allow the species unimpeded volitional access to historical spawning and rearing habitats. Such historical habitats are often situated in protected areas such as National Forests, and exhibit critical characteristics such as suitable substrate, sustained base flows, and refugia such as pool habitats. Besides allowing access to historical habitats, dam modification provides additional ecological benefits that are essential to attaining the recovery objectives. Such benefits include maintaining genetic and ecological diversity, population abundance, growth rates, and buffering against natural and anthropogenic catastrophic disturbances (*e.g.,* wildfires, droughts, debris flows) though restoration of the natural spatial population structure of the Southern California Steelhead DPS. Mechanistic solutions to fish passage such as trap-and-truck operations are problematic for a variety of reasons, including: the limitations in the operations during high flows when fish are most like 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. They are therefore are not expected to effectively abate the threat posed by dams which block fish

passage. See for example, Cada, *et al.* 1993, 1995; Caudill, *et al*. 2007; Colt and White (eds.) 1991; Fleming, *et al.* 1991; Godinho *et al.* 1991; Lucas, and Baras. 2001; Oldani and Baigum 2002; Nemeth and Kiefer 1999; Pompeu and Martinez 2007. If dam modification (including removal or breaching) is determined to be technically or economically infeasible, alternative approaches for providing sustainable volitional passage of steelhead must be implemented. The selected alternative must be expected to provide ecological benefits that are similar to expected benefits from dam removal or breaching.

Water storage (*e.g.,* reservoirs, managed groundwater Watersheds) and withdrawals (*e.g.,* groundwater pumping, surface-water diversions) can have the effect of altering the pattern and magnitude of streamflow. Recovery Objectives 2 and 5 include the restoration of steelhead distribution to previously occupied areas and the restoration of suitable habitat conditions and characteristics for all life-history stages of steelhead. Threats abatement criteria identified to meet these objectives include the restoration and protection of these habitat conditions and characteristics. The essential recovery actions involve either halting the alteration of the pattern and magnitude of streamflow where and when such an option is available, or implementing measures (*e.g.,* operating criteria) to ensure that a more natural (*i.e.,* pre-impact timing, frequency, duration, magnitude, and rate-of-change) streamflow is restored. There are many sites within core watersheds where past and present anthropogenic activities continue to alter the pattern and magnitude of streamflow and for which critical recovery actions are identified. In some situations, other actions to address impassable barriers may fully or partially eliminate threats to the pattern and magnitude of streamflow, thereby addressing two principal threats to the species: physical blockage of fish passage, and reduction or elimination of surface flows. The restoration of natural flow regime will also contribute toward restoring rearing habitats.

Regarding rearing habitats, fast juvenile growth is one 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 which provide suitable over-summering habitat. The identification, protection, and where necessary, restoration of such habitats is therefore another critical recovery action.

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

Finally, conservation hatcheries may contribute to the recovery of the Southern California Steelhead 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) reintroduction of populations in restored watersheds; and (3) augmentation of small populations to accelerate the rate of recovery. Issues which 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, reestablishment or supplementation, and (3) protocols for evaluating the effectiveness of such conservation hatchery functions over time. Conservation hatcheries and species' establishment program should not serve as surrogates for establishing and preserving essential habitat functions for endangered steelhead particularly where anthropogenic activities have created threats that constrain or eliminate habitat functions and values. Regarding the first function, raising (or rescuing) and releasing juveniles can require a considerable expenditure of resources for a relatively small biological return because of the naturally low productive rate of juvenile fish, the majority of which subsequent to supplementation or rescue and releasing will die in the ocean before reproducing as adults. Additionally, such program could result in the unintentional survival of smaller smolts as a result of being freed from natural rearing competition, rather than larger (though fewer) smolts with a higher ocean survival rate. (For additional discussion of the role of conservation hatcheries see Chapter 13, "Research, Monitoring, and Adaptive Management".)

Table 6-2. Critical recovery actions for Core 1 *O. mykiss* populations within the Southern California Steelhead DPS.

BPG	POPULATION	CRITICAL RECOVERY ACTION
Monte Arido Highlands	Santa Maria River	Implement operating criteria to ensure the pattern and magnitude of water releases from Twitchell Dam comport with the natural or pre-dam pattern and magnitude of streamflow. Physically modify Twitchell Dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.
	Santa Ynez River	Implement operating criteria to ensure the pattern and magnitude of water releases from Bradbury, Gibraltar, and Juncal dams comport with the natural or pre-dam pattern and magnitude of streamflow. Physically modify Bradbury, Gibraltar, and Juncal dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.
	Ventura River	Implement operating criteria to ensure the pattern and magnitude of water releases from Casitas, Matilija, and Robles Diversion dams comport with the natural or pre-dam pattern and magnitude of streamflow. Physically modify Casitas, Matilija, and Robles Diversion dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.
	Santa Clara River	Implement operating criteria to ensure the pattern and magnitude of water releases from Vern Freeman Diversion, Santa Felicia, Pyramid, and Castaic dams comport with the natural or pre-dam pattern and magnitude of streamflow. Physically modify Vern Freeman Diversion, Harvey Diversion, Santa Felicia, and Pyramid dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.
Conception Coast	Mission Creek, Carpinteria Creek, and Rincon Creek	Halt the unnatural dry-season reduction in the amount and extent of surface water to restore natural or pre-impact over-summering habitat characteristics and condition for steelhead. Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.
Santa Monica Mountains	Malibu Creek	Remove Rindge and Malibu dams, and physically modify road crossings, to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.
Mojave Rim	San Gabriel River	Implement operating criteria to ensure the pattern and magnitude of water releases from Morris, San Gabriel, and Cogswell dams comport with the natural or pre-dam pattern and magnitude of streamflow in downstream reaches. Physically modify Morris, San Gabriel, Cogswell, and Santa Fe dams, and road, highway, and railway crossings to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.
Santa Catalina Gulf Coast	San Juan Creek	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.
	San Luis Rey River	Implement operating criteria to ensure the pattern and magnitude of water releases from Pilgram, Turner, Lower and Upper Stehly, Aqua Tibia, Henshaw, and Eagles Nest dams comport with the natural or pre-dam pattern and magnitude of streamflow in downstream reaches. Physically modify all dams, and road, highway, and railway crossings to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify protect, and where necessary, restore estuarine and freshwater rearing habitats.

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

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

We identify restoring steelhead access to historical spawning and rearing habitats (*i.e.,* areas upstream of introduced barriers that are currently unoccupied by anadromous *O. mykiss*) as an essential action for recovering endangered steelhead. In this section, we summarize the ecological rationale for this specific recovery action. Central to the rationale is the historical steelhead population structure and distribution, and the necessity of historical habitats for reducing extinction risk and increasing population growth rate (*i.e.,* the productivity of a population).

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

Native steelhead historically existed in areas that are currently inaccessible

Knowing where the species existed prior to the construction of migration barriers is essential for identifying the watersheds where restoring access to historical spawning and rearing habitats would be appropriate. Based on an extensive review of the distribution of the species we have reliable scientific information indicating the specific coastal watersheds where steelhead historically existed (Boughton *et al*. 2006). Investigation of the genetic structure of juvenile *O. mykiss* collected from freshwater habitats, including instream areas upstream of migration barriers within Core 1 populations, confirm that the present-day populations are dominated by ancestry of indigenous southern coastal steelhead (Nielsen *et al.* 1997, Clemento *et al.* 2008). Populations of *O. mykiss* that exist upstream of introduced barriers are largely or entirely descended from relic *O. mykiss* populations ascending the watersheds historically. These findings as well as the intrinsic potential of certain watershed-specific populations for recovering this species (e.g., Boughton *et al*. 2006) contribute to NMFS' basis for recommending that steelhead access be restored, especially within Core 1 populations.

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

Artificial migration barriers are a major cause of habitat loss and fragmentation within the endangered Southern California DPS of steelhead, and have resulted in a high risk of species' extinction. Restoring steelhead access to historical habitats is necessary to reduce extinction risk to a level that is considered negligible over a 100-year period. Understanding how this recovery action would reduce extinction risk requires knowledge of the factors that affect extinction risk and population growth rate.

Population extinction risk is related to the numerical abundance of the population, which itself is related to the extent that the species is distributed over space (*i.e.,* population spatial structure)

and the degree that diversity of life history traits is not restricted. Small populations with limited spatial structure are particularly susceptible to extinction, owing to their increased susceptibility to demographic and environmental fluctuations, and loss of genetic variability. With regard to life history traits, steelhead possess a suite of traits, such as anadromy, timing of spawning, emigration, and immigration, fecundity, age-at-maturity, behavior, physiological and genetic characteristics. The more diverse these traits (or the more these traits are not restricted), the more likely the species is to survive a spatially and temporally fluctuating environment (McElhany *et al*. 2000). Overall, the greater a species' geographic distribution and the less constrained the diversity of life history traits, the more likely the species is able to withstand stochastic environmental variation and achieve and maintain a rate of population growth that is viable (*i.e.,* reduces the extinction risk to a negligible level).

With regard to the endangered Southern California DPS of steelhead, evidence indicates anthropogenic activities have severely truncated population spatial structure and eliminated certain life history traits. While the species was historically widespread, artificial migration barriers have resulted in populations that are sparsely distributed over space and significantly reduced in number. These barriers prevent steelhead from migrating within rivers and to and from the ocean, a critical part of the species' life cycle. Barriers preclude steelhead from accessing spawning habitats and interacting with the freshwater form of *O. mykiss*, both of which are necessary to produce young and withstand stochastic environmental fluctuations.

As a result, specific areas within the broader geographical area that is occupied by the species are inadequate for conservation of the species (*e.g.,* Boughton *et al*. 2005, Good *et al.* 2005, Boughton *et al*. 2007, Gustafson *et al*. 2007, NMFS 2008a). The available information demonstrates that unoccupied areas are essential for the conservation and recovery of the species.

The means for increasing population growth rate depends, in large part, on the factors that have caused the species to experience a high risk of becoming extinct. The available information that is the basis of this recovery plan demonstrates that loss of historical spawning and rearing habitats through the construction of artificial migration barriers, and elimination of critical life history traits (*e.g.,* migration, interaction and exchange between the anadromous and resident forms of *O. mykiss*), are central reasons for the high risk of extinction. 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 involves giving back essential habitats to steelhead and restoring ecological traits that are critical for the species to complete its life cycle. Restoring steelhead access to historical habitats would achieve these objectives. The foregoing is the principal recovery strategy embodied in this recovery plan.

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

The available information describing the abundance and distribution of *O. mykiss* demonstrates that historical habitats possess the capability 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. Fishery investigations performed in selected coastal watersheds by state and federal resources agencies and academia (*e.g*., Moore 1980, Deinstadt *et*

al. 1990, Douglas 1995, Carpanzano 1996) report on the abundance and distribution of *O. mykiss*, including in areas upstream of artificial barriers within Core 1 populations. These investigations indicate that the existing habitats are suitable for spawning and rearing of *O. mykiss*, as evident by the finding of young-of-the-year and older juvenile trout. Inferring the existence of suitable habitat for the anadromous form of *O. mykiss* based on the presence of the resident form is reasonable and ecologically appropriate given that the resident and anadromous forms simply represent different life histories of the same species.

With regard to the amount of suitable steelhead habitat, the findings of fishery investigations and habitat evaluations that report the amount of habitat in the basin indicate the existence of hundreds of miles of stream network across the Core 1 populations. Numerous streams within Core 1 populations provide an extensive amount of habitat (*e.g.*, Moore 1980, Thomas R. Payne and Associates 2003), which we know is capable of supporting spawning and rearing because reproduction and rearing of multiple age groups and life stages of *O. mykiss* have been documented (*e.g.*, Moore 1980, Deinstadt *et al*. 1990, Douglas 1995, Carpanzano 1996). The extensive habitat is expected to produce a large number of steelhead.

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 regard to 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 is not insurmountable because such activities are commonly undertaken to restore habitat characteristics and condition for populations of stream fish (*e.g.*, Smith *et al*. 2000, The Heinz Center 2002). Locally, NMFS has collaborated with project proponents on a variety of fish-passage projects that have involved removal or modification of a highway structure, diversion, or dam for the purpose of either improving or restoring migration of steelhead to historical spawning and rearing habitats. NMFS is currently collaborating with stakeholders on the restoration river ecosystems including the Ventura River in California and the Elwha River in Washington, both of which require the removal of dams to allow anadromous salmonids access to historical habitats.

With regard to the expected success from restoring steelhead migration to historical habitats, the available information indicates that restoring steelhead access to historical spawning and rearing habitats would increase population growth rate. Making barriers passable for migratory species has the functional effect of restoring fish access to historical spawning and rearing habitats – effectively increasing breeding and living space for the species. Given the extensive amount of stream network upstream of the barriers within Core 1 populations alone (estimates indicate several hundred miles of stream network exist), we expect historical habitats to be capable of producing a large number of steelhead.

Another reason we expect the recovery action would increase population growth rate involves the existing character of the historical habitats. Information indicates the historical habitats are serving as a refuge freshwater habitat that is safeguarding the anadromous species. Reproduction of *O. mykiss* and extensive suitable habitat has been noted upstream of introduced barriers (*e.g.*, Moore 1980, Deinstadt *et al*. 1990, Douglas 1995) as well as *O. mykiss* that exhibit ancestral native steelhead genetics (Nielsen *et al*. 1997, Clemento et al 2008). These fish possess the ability to transform into smolts and migrate to the ocean (*e.g.*, Thrower *et al*. 2004). Even today, large adult *O. mykiss* leave the freshwater lakes that have formed behind dams and undertake steelhead-like migrations during the wet season and spawn in upstream tributaries (Bloom 2005). The characteristics of the populations upstream of artificial migration barriers, and the quantity and quality of habitat, suggest the areas would support a large and naturally reproducing population for the purpose of conserving this endangered species.

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 endangered steelhead). First, an increase in population spatial structure would be observed. The spatial structure of a population is important because the spatial distribution can affect evolutionary processes and, therefore, alter the ability of a population to adapt to spatial or temporal changes in the species' environment. Populations that are thinly distributed over space are susceptible to experiencing poor population growth rate and loss of genetic diversity, and are more likely to not withstand the effects of widely fluctuating environmental conditions.

Second, ecological interactions between the resident and anadromous form of *O. mykiss* would be restored, thereby contributing to the viability of the anadromous form. The two life-history forms can be sympatric and genetically similar (Docker and Heath 2003, Narum *et al*. 2004, McPhee *et al*. 2007) and the resident form can produce anadromous progeny and vice versa (Zimmerman and Reeves 2000, McPhee *et al*. 2007). These findings emphasize the survival advantage of the resident form to the anadromous form of *O. mykiss*, particularly under certain environmental conditions. Extended periods of no or low rainfall can limit migratory conditions and preclude steelhead from reaching freshwater spawning areas. During such periods, resident *O. mykiss* can be the only life-history form spawning and producing progeny with the innate ability to resume anadromy, which favors future persistence of the anadromous form. By contrast, the anadromous form can recolonize watersheds following periods of extended drought and temporary extirpation of the resident form.

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*. 2007). Some of these traits involve the capability to migrate long distances and tolerate elevated water temperatures. Many coastal watersheds supporting Core 1 populations extend considerably inland, which requires that steelhead have the physical ability to migrate long distances to access spawning areas in upper reaches. 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 tolerate elevated water temperature and modest habitats is particularly important for increasing genetic and ecological diversity.

Fourth, the expected increase in population growth rate is projected to favor increased abundance in neighboring Core 2 and Core 3 populations. When restored to an "unimpaired" condition, Core 1 populations are expected to support formation of steelhead numbers in adjacent population units. The creation and maintenance of populations in several adjacent population units effectively increases numbers of individuals in the broad population (*i.e.,* scale of the DPS). Given the risk of extinction that small populations face (*e.g.*, Pimm *et al*. 1988, Primack 2004), a larger number of individuals decrease the risk that the broad population would possess weakened viability.

6.4 CRITICAL RESEARCH NEEDS FOR RECOVERY

Successful implementation of the recovery plan and measurement of the species' progress towards recovery requires two critical elements of scientific research and monitoring: (1) population abundance monitoring within core watersheds and (2) other research efforts in core watersheds to develop more refined biological recovery criteria. As discussed in Chapter 5, 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 southern California.

Research efforts should be focused on developing a better understanding of the following topics: 1) reliability of migration corridors; 2) productivity of freshwater tributary nursery areas; 3) evaluation of role of seasonal lagoons, particularly for juvenile rearing; 4) productivity of freshwater mainstem habitats; 5) roles of intermittent freshwater habitats for both spawning and rearing; 6) spawner density as an indicator of individual population viability; 7) relationship between anadromous (steelhead) and non-anadromous (resident) forms and population structure and viability; and, 8) rates of dispersal between individual populations. With respect to topics 2 through 4, the aim is to identify and protect, and where necessary, restore, those habitats which specifically promote the anadromous life-history form, by among other things producing high number of fast-growing and large smolts, and avoid inadvertently promoting only the freshwater life-history form of *O. mykiss*. In addition to these biological research topics, research into basic habitat dynamics should be conducted to provide additional direction in habitat protection and restoration. Such research includes the effects of the wildland fire regime and climate change effects on freshwater habitat; environmental factors that affect freshwater temperatures; and, factors producing freshwater refugia that sustain *O. mykiss* during seasonal or prolonged droughts.

Chapter 13 further details the recommended research and monitoring program NMFS believes is necessary for the successful implementation of the recovery program. This program is currently in draft form and subject to revision as comments are offered by scientific experts and as new information further refines the questions and criteria that are the subject of research efforts.

6.5 RECOVERY STRATEGIES TO ADDRESS CLIMATE CHANGE AND MARINE ENVIRONMENT VARIABILITY

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

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

This component encompasses such restoration activities as removing passage to prime upstream spawning and rearing habitats; restoring flow regimes which are essential for both adult and juvenile instream migration; regulating flood control and other instream activities which 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 SCS Recovery Planning Area is intended to allow the species to continue to evolve adaptations to cope with a dynamic and challenging environment.

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

7. Summary of DPS-wide Recovery Actions

"The basic recovery strategy reflected in the identified recovery actions mimics the strategy that the species exhibits in its natural distribution among the various watersheds in their unaltered state, and provide the most effective strategy for conserve the natural diversity (genetic, phenotypic and behaviors) and redundancy of the populations necessary to ensure the long-term viability of individual populations, and the listed species as a whole."

Southern California Coast Steelhead Recovery Planning Area: Recovery Actions
Hunt & Associates 2008

The SCS Recovery Planning Area is characterized by severe to very severe degradation of habitat conditions along the lower mainstem rivers where development is concentrated, while the upper mainstem and tributaries, often situated within the four southern California National Forests, retain relatively high habitat values for anadromous *O. mykiss*. Because the mainstems of these drainages are the conduits that connect upstream spawning and rearing habitats with the ocean, recovery actions in watersheds impaired in this manner focus on reducing the severity of anthropogenic impacts along the mainstems resulting from encroachment into riparian areas and related flood control activities in order to promote connectivity between the ocean and upstream spawning and rearing habitats. Additionally, degraded estuarine conditions stemming from filling, artificial sandbar manipulation, and both point and non-point waste discharges are addressed by specific recovery actions for the SCS Recovery Planning Area.

This chapter describes DPS-level recovery actions and provides a narrative description of widespread watershed-specific recovery actions. DPS-level recovery actions are recommendations that are designed to address widespread and often multiple threat sources across the range of the DPS 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 southern California steelhead. Many of these causes of decline are systemic and persistent, crossing numerous environmental and political boundaries. The sources and reasons for decline are identified in Federal Register Notices and this recovery plan. Effectively addressing these causes of decline involves multiple challenges and opportunities that include: (1) development of new and effective implementation of current laws, policies, and regulations; (2) securing adequate funding for recovery implementation; (3) developing strategic

partnerships; (4) assuring effective prioritization of restoration, threat abatement, and monitoring actions; and (5) conducting education and outreach.

7.1 DPS-WIDE RECOVERY ACTIONS

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

- Work with owners, operators, local, state and federal agencies to implement operating criteria to ensure the pattern and magnitude of water releases from water storage and diversion facilities such as those listed in Table 6-2 and the recovery action tables comport with the natural or pre-dam pattern and magnitude of streamflow.
- Physically modify passage barriers such as the dams and diversion facilities listed in Table 6-2 and the recovery action tables to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Examples of important fish passage barriers identified include: Robles Diversion on the Ventura River, Matilija Dam on the Ventura River, Vern Freeman Diversion on the Santa Clara River, and Rindge Dam on Malibu Creek;
- Encourage CDFG and NMFS to finalize and implement the Statewide Coastal Monitoring Plan. Implementation of the Statewide Coastal Monitoring Plan is essential for evaluating the long-term viability of southern California steelhead as well as other species of listed salmonids in California;
- Prioritize restoration funds, notably the Pacific Coast Salmon Restoration Fund and California's FGRP, in Core 1 watersheds.
- Promote restoration projects to provide access to historic steelhead spawning and rearing habitats and increase egg-to-smolt life-stage survival;
- Encourage appropriate agencies to secure funding for, and engage in, full enforcement of relevant laws, codes, regulations and ordinances protective of steelhead and their habitats;
- Work with CalTrans, counties, and others with oversight on road practices to reduce or remove transportation-project-related barriers to upstream and downstream passage including railroads and similar structures;
- Inventory and assess impediments to fish passage and identify and provide appropriate fish passage opportunities in the watersheds historically supporting anadromous runs within the southern range extension (Mojave Rim and Santa Catalina Gulf Coast BPGs);
- Enhance protection of natural in-channel and riparian habitats, including adequate control of flood-control activities (both routine maintenance and emergency measures), off-road vehicle use, and in-river sand and gravel mining practices to be commensurate with habitat and life-history requirements of steelhead.
- Reduce water pollutants such as fine sediments, pesticides, and other non-point source, and point source waste discharges commensurate with habitat and life-history requirements of steelhead. This should be accomplished through watershed and management and regulation of public and private facilities releasing waste-discharges.

- ❑ Close remaining areas currently open to angling below impassible barriers of all anadromous waters; in anadromous watersheds, assess impacts of angling on native *O. mykiss* above barriers which are currently impassible to upstream-migrating steelhead.
- ❑ Eliminate the stocking of hatchery-reared fish in anadromous waters. Where stocking is otherwise appropriate, use sterile triploid fish in all waters where stocked fish may enter anadromous waters.
- ❑ Convene a committee of agency and institutional scientists (*e.g.*, the DFG, NMFS' Fisheries Science Centers, U. Fish and Wildlife Service) for the purpose of developing guidelines for the management and operation of a conservation hatchery program for endangered steelhead. NMFS would implement the guidelines, which will be consistent with the overall purpose of preserving the natural genetic and phenotypic characteristics that promote life-history variability through captive broodstock, supplementation, and gene-bank programs, and reducing the short-term or immediate risk of extinction to the species.
- ❑ Assess the condition of and restore estuarine habitats through the control of fill, waste discharges, and establishment of buffers, to be commensurate with the habitat and life-history requirements of steelhead.
- ❑ Control artificial breaching and/or draining of coastal estuaries to be commensurate 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, up-graded, 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.
- ❑ Conduct research on the relationship between resident and anadromous forms of *O. mykiss*, and the population dynamics (*e.g.*, distribution, abundance, residualization, homing/straying, and recolonization rates); extend genetic research and analysis to include the southern range extension (Mojave Rim and Santa Catalina Gulf Coast BPGs).
- ❑ Identify an appropriate institution or facilities and develop the necessary authorization for the permanent curation of deceased *O. mykiss* specimens for the purpose of making available specimens for examination and study to present and future scientific researchers.
- ❑ Monitor annual fluctuations of *O. mykiss* populations (anadromous and resident) in larger inland rivers systems and short coastal streams in all BPGs.
- ❑ Survey and monitor the distribution and abundance of non-native species and plants and animals that degrade natural habitats or compete with native species within larger river systems and short coastal streams identified as core populations. Initiate efforts to eliminate, reduce, or control such non-native, invasive species.
- ❑ Encourage amendments to Army Corps 404 Clean Water Act exemptions for farming, logging, and ranching activities; terminate Section 404(f) exemptions for discharges of dredged or fill material into US waters (channelization) associated with agriculture, logging, ranching and farming;

- Work with Federal and State agencies to coordinate and develop programmatic permits for incidental take authorization for actions that contribute to the recovery of southern California steelhead and their habitats.

7.2 RECOVERY ACTION NARRATIVES

Table 7-1 contains a narrative description of recovery actions common throughout many of the watersheds discussed within this recovery plan. These narratives provide specific information on the objectives and steps required to implement recovery actions summarized in the recovery action tables for each watershed in later chapters. Parties implementing actions within each watershed should use the narratives within this table to understand the recommended recovery actions.

Table 7-1. Recovery Actions Glossary

Threat Source	Recovery Action	Detailed Description
Agricultural Development	Develop, adopt, and implement agricultural land-use planning policies and standards	Develop, adopt, and implement land-use planning policies and development standards that restrict further agricultural development within the floodplain/riparian corridor to protect *all O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Relocate livestock grazing and water sources	Develop and implement a plan to relocate livestock grazing outside a 100-foot wide riparian buffer on either side of the channel and estuary to protect instream and riparian habitats essential for all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats. Develop and implement a plan to provide alternative upland water sources for livestock.
	Relocate agricultural development and restore riparian zone	Develop and implement a plan to relocate agricultural development in the floodplain to create a minimum 100-foot wide riparian buffer from the edge of the riparian corridor or top-of-bank (whichever is greater); restore and revegetate a minim 100-foot wide buffer to allow the channel to re-establish natural structural diversity to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Develop and implement a watershed-wide sediment management plan	Develop and implement a watershed-wide sediment management plan that identifies sources of sediment input (and related agriculturally generated nutrients) and effects on benthic habitats, and prescribes remediation measures which will protect *all O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
Agricultural Effluents	Develop and implement a plan to minimize runoff from agricultural activities	Develop and implement a plan to reduce or eliminate nutrient runoff and sediment inputs into natural watercourses from agricultural activities to provide water quality suitable for all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitat conditions.
Dams and Surface Water Diversions	Develop and implement water management plan	Develop and implement a water management plan for the mainstem and major tributaries to identify the maximum diversion rates for surface water diversions that will maintain surface flows necessary to support all *O. mykiss* life-history stages, including unimpeded adult and juvenile *O. mykiss* migration, and suitable spawning and rearing habitat conditions.
	Develop and implement operational plan for selected dams	Develop and implement an operational plan to provide seasonal releases from selected dams necessary to provide surface flows in the mainstem necessary to support all *O. mykiss* life-history stages, including adult and juvenile *O. mykiss* migration, spawning, incubation and rearing, and their associated habitats.
	Provide fish passage around selected dam or diversion or remove barriers	Develop and implement a plan to provide seasonal unimpeded fish passage for adult and juvenile *O. mykiss* around selected dam or diversion to provide access to upstream spawning and rearing habitats.
	Remove Dam	Where applicable, Implement plans to remove selected dams to provide unimpeded fish passage for adult and juvenile O. mykiss and restore the reservoir area to provide access to upstream spawning and rearing habitats and to support all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Conduct hydrological analysis (dam releases)	Conduct hydrological analysis to determine seasonal releases (timing, duration and magnitude) from selected Dams necessary to necessary to support all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.

Threat Source	Recovery Action	Detailed Description
Culverts and Road Crossings (Passage Barriers)	Develop and implement a plan to remove or modify all identified fish passage barriers within the watershed	Develop and implement a plan to remove or modify all fish passage barriers identified within the watershed to provide unimpeded adult and juvenile *O. mykiss* migration between the estuary and upstream spawning and rearing habitats, and reduce intrusion into the riparian corridor. (see relevant Steelhead Assessment and Recovery Opportunities reports for Southern CA counties and watersheds)
	Conduct a watershed-wide fish passage barrier assessment	Conduct a watershed-wide fish passage barrier assessment between the ocean and all upstream spawning and rearing areas. This passage barrier assessment should utilize the protocols identified in the California Department of Fish and Game's California Salmonid Stream Habitat Restoration Manual (2003).
Flood Control	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation	Develop and implement a flood control maintenance plan to minimize the frequency and intensity of disturbance of instream habitats and riparian vegetation (e.g., modification of natural channel morphology and removal of native vegetation) of the mainstem and tributaries to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
Groundwater Extraction	Conduct hydrological analysis (groundwater)	Conduct hydrological analysis to identify groundwater extraction regimes' effect on the natural pattern (timing and duration) and magnitude of surface flows in the mainstem, tributaries, and the estuary.
	Develop and implement a groundwater monitoring program	Develop and implement a groundwater monitoring program to guide management of groundwater extractions to provide surface flows necessary to support all *O. mykiss* life-history stages, including adult and juvenile *O. mykiss* migration, spawning, incubation and rearing, and their associated habitats.
Levees and Channelization	Develop and implement a plan to restore natural channel features where feasible	Develop and implement a plan to modify channelized portions of the mainstem and tributaries wherever feasible to restore natural channel features, 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, and their associated habitats.
	Develop and implement a flood control maintenance program	Develop and implement a flood control maintenance program that minimizes the frequency and intensity of disturbance of instream habitats and riparian vegetation (e.g., modification of natural channel morphology and removal of native vegetation) to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees	Develop and implement a plan to vegetate levees with native, naturally occurring vegetation wherever feasible and minimize the use of herbicides to control native vegetation adjacent to existing levees to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Develop and implement a 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 artificial bank stabilization; wherever feasible, remove rip-rap and other artificial bank stabilization features on mainstem and tributaries and replace with bio-engineered bank stabilization.
	Develop and implement a plan to abandon artificial channels	Develop and implement a plan to abandon artificial channels; create new natural channel that allows for natural channel morphology (e.g., meanders, etc.) and unimpeded access for adult and juvenile migration to upstream spawning and rearing habitats.

Threat Source	Recovery Action	Detailed Description
Mining and Quarrying	Review and modify aggregate mining operations	Review aggregate mining operations (past, current and future) for conformance with the National Marine Fisheries Services Guidelines for Removal of Sediment from Freshwater Salmonid Habitat (2004). Modify aggregate current and future operations, where necessary to comply with the relevant provisions of the guidelines, and remediate past or terminated operations to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Develop and implement a plan to remove and maintain quarry and landslide debris from the channel	Develop and implement a plan to remove quarry debris and landslide from the channel, maintain the channel free from such debris, and establish a minimum 50-foot riparian buffer with native, locally occurring species at rock quarry, to protect all O. mykiss life-history stages, including adult and juvenile *O. mykiss* migration, and spawning and rearing habitats.
Non-Native Species	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures	Develop and implement a watershed-wide plan to identify and determine the distribution and density of non-native species, assess their impacts on all *O. mykiss* life-history stages, and eliminate or control non-native species of plants and animals (particularly fish and amphibians); restore riparian and upland areas with native, locally occurring plant species to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Develop and implement a non-native species monitoring program	Develop and implement an on-going monitoring program to track the status and impacts of non-native species of plants and animals on all *O. mykiss* life-history stages, particularly rearing juveniles.
	Develop and implement a public educational program on non-native species impacts	Develop and implement a public education program (including signage at public access points) to inform the general public of the adverse effects of introducing non-native species into natural ecosystems.
Other Recovery Actions	Develop and implement an estuary restoration and management plan	Develop and implement a restoration and management plan for the relevant Estuary. To the maximum extent feasible, the plan should include restoring the physical configuration, size and diversity of the wetland habitats, eliminating exotic species, controlling artificial breaching of the sand bar, and establishing a minimum buffer to restore estuarine functions and promote *O. mykiss* use (including rearing and acclimation) of the estuary.
	Review and modify applicable County and/or City Local Coastal Plans	Review applicable County and/or City Local Coastal Plans and modify to provide specific provisions for the protection of all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Review applicable Integrated Natural Resources Management Plans	Review the Vandenberg Air Force Base Integrated Natural Resources Management Plan and modify to provide specific provisions for the protection and restoration of all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
Roads	Relocate roadways outside of riparian corridor and restore abandoned roadways	Develop and implement a plan to relocate roads outside of a 300-foot wide riparian/floodplain corridor wherever feasible; restore and re-vegetate abandoned roadways with native, locally occurring species to reduce sedimentation and protect all steelhead life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitat conditions.
	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 pollutants before it enters natural watercourses to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.

Threat Source	Recovery Action	Detailed Description
Roads (continued)	Develop and implement a plan to remove or reduce approach-fill for relevant railroad lines and roads	Develop and implement a plan to remove or reduce approach-fill for relevant railroad lines and roads and maximize the clear spanning of upstream active channel, floodway, and floodplain to accommodate natural river and estuarine fluvial processes.
Recreational Facilities	Develop, adopt, and implement recreational land-use planning policies	Develop, adopt, and implement land-use policies to prohibit off-road vehicular activity within the riparian/floodplain corridor of the mainstem and tributaries necessary to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Review development and management plans for selected parks and national forests	Review development and management plans for selected parks 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, and their associated habitats. Provide specific provisions for the restoration and protection of creeks, rivers, estuaries, wetlands and riparian/floodplain areas, including a minimum 100-foot setback for all development from estuarine and riparian habitats. Regulate the use of day-use areas and other recreational facilities to minimize impacts to aquatic and wetland habitats to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing.
	Develop and implement a public educational program on watershed processes	Develop and implement a public educational program (including signage at public access points) to promote public understanding of watershed processes (including the natural fire-cycle) and *O. mykiss* ecology to protect all O. mykiss life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
Urban Development	Develop, adopt, and implement urban land-use planning policies and standards	Develop, adopt and implement land-use planning policies and development standards that restrict further development in the floodplain/riparian corridor to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Retrofit storm drains in developed areas	Develop and implement a plan to retrofit storm drains in developed areas to filter sediments and 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, and their associated habitats.
	Develop and implement a riparian restoration plan that focuses on replacing artificial bank stabilization structures wherever feasible	Develop and implement a riparian restoration plan throughout the mainstem and tributaries that focuses on replacing artificial bank stabilization structures wherever feasible to create a minimum 50-foot wide riparian buffer on either side of mainstem and tributaries, and re-vegetate with native, locally occurring species.
Urban Effluents	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans, and any applicable Stormwater Permit, and modify to provide specific provisions for the protection of all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.
	Review, assess and modify if necessary all NPDES wastewater discharge permits	Review and assess all National Pollution Elimination Discharge System (NPDES) wastewater discharge permits to determine effects of discharge on adult and juvenile *O. mykiss* migration, spawning, and rearing habits. Modify discharge requirements, if necessary, to ensure discharge is adequate to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated habitats.

Threat Source	Recovery Action	Detailed Description
Urban Effluents (continued)	Review, assess and modify, if necessary, residential wastewater septic treatment facilities	Review and assess residential wastewater septic treatment facilities to determine effects of discharge on adult and juvenile O. mykiss migration, spawning, and rearing habits. Modify septic systems, if necessary, to ensure discharge is adequate to protect all *O. mykiss* life-history stages, including adult and juvenile migration, spawning, incubation and rearing, and their associated 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 deposition)

8. Monte Arido Highlands 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 the South-Central and Southern California, 2007

8.1 LOCATION AND PHYSICAL CHARACTERISTICS

The Monte Arido Highlands BPG region encompasses four medium to large coastal watersheds and eight sub-watersheds that drain the western half of the Transverse Range in southern San Luis Obispo, Santa Barbara, Ventura, and eastern Los Angeles counties. The Santa Maria River watershed proper is a small, coastal drainage formed by the confluence of two large interior watersheds: the Cuyama River and the Sisquoc River, which together drain most of the Sierra San Rafael, Sierra Madre, and Caliente ranges.

The Santa Ynez River drains the south-facing slopes of the Sierra San Rafael and north-facing slopes of the Santa Ynez Mountains. The Santa Maria Rivers drains a coastal subsidence Watershed formed by crustal elongation and clockwise rotation of the Santa Ynez Mountains. The Ventura River drains the coastal slopes of the eastern end of the Santa Ynez Mountains and the western end of the Transverse Range. The Santa Clara River drains much of the western Transverse Range, including the northern slopes of the San Gabriel Mountains. The mainstems of the Santa Maria and Santa Ynez rivers are oriented east-to-west and discharge to the Pacific Ocean in western Santa Barbara County. The Ventura and Santa Clara watersheds abut the upper watersheds of the Santa Maria and Santa Ynez rivers, but their mainstems flow south and southwest into the Pacific Ocean in southern Ventura County (Figure 8-1).

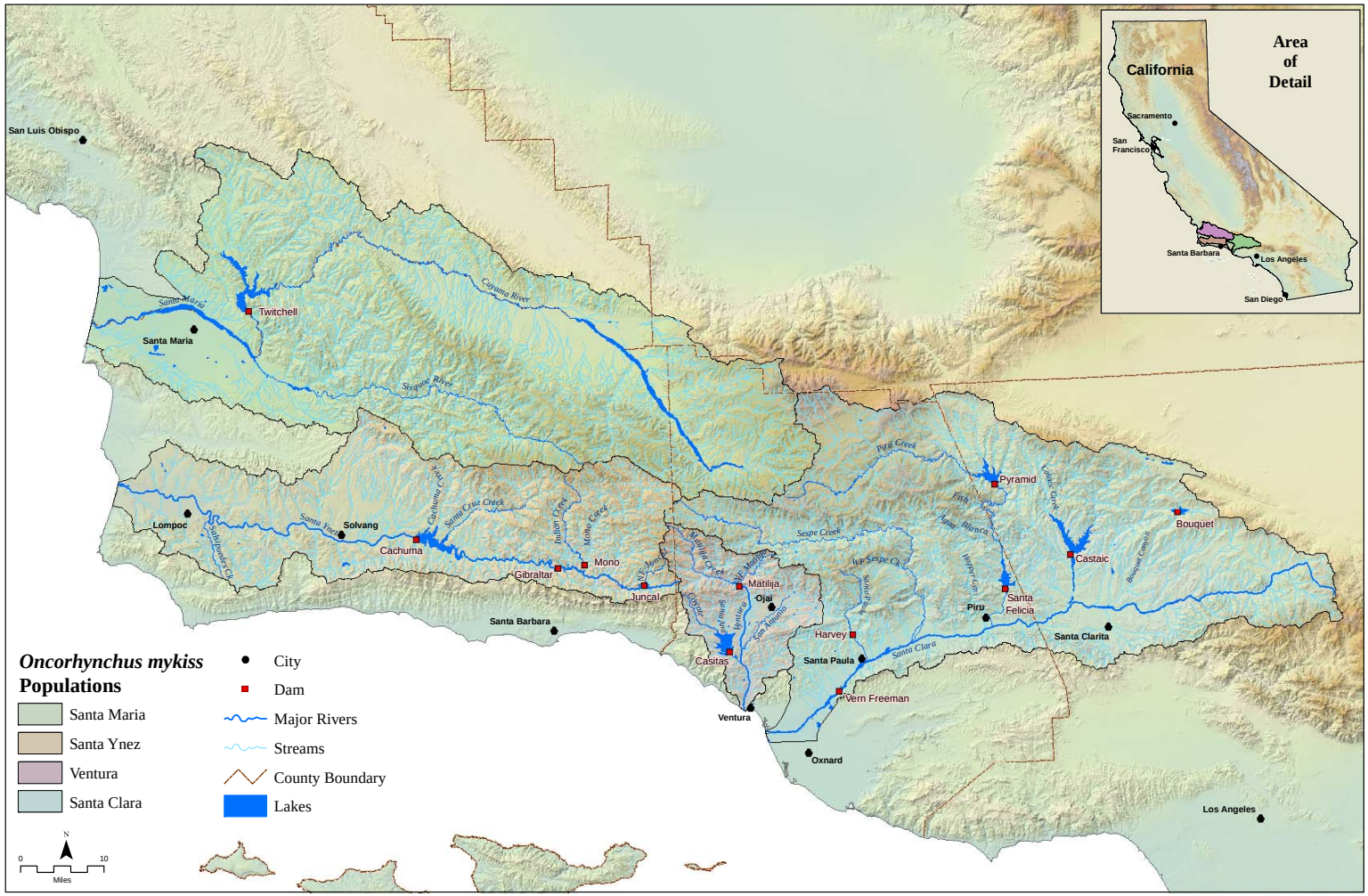

Figure 8-1. The Monte Arido Highlands BGP region. Thirteen populations/watersheds were analyzed in this region: three in the Santa Maria River watershed; one in the Santa Ynez River watershed, five in the Ventura River watershed, and four in the Santa Clara River watershed.

These watersheds are highly disparate in terms of slope, aspect, and size, but share one common feature: the interior portions are mountainous and include high peak elevations, ranging between 5,700 and 8,600 feet above sea level. Each of these watersheds flows across a coastal terrace, but the Santa Maria, Santa Ynez, and Santa Clara rivers traverse broad coastal plains before entering the Pacific Ocean. Overall, stream lengths tend to be very long, owing to high topographic relief in the interior watersheds. The Santa Maria River watershed (Cuyama River sub-watershed) extends the furthest inland—almost 90 miles between the mouth and the limits of the upper watershed.

Average annual precipitation in the Santa Maria River and Santa Clara River watersheds is much lower than the other two because the former include extensive arid interior regions. Although rainfall amounts generally increase with elevation, such orographic (*i.e.,* lifting) effects are concentrated in the most coastal mountainous portions of these watersheds, and much of the interior portions lie in "rain shadows" of the coastal portions of the watersheds.

For example, Old Man Mountain at 5,500 feet above sea level in the Ventura River watershed not only receives five to ten times the amount of precipitation that falls on lower coastal locations only a few miles away, but also receives much more rainfall than interior peaks of comparable elevation in this region. The drainages in these watersheds exhibit "flashy" flow patterns during and after storm events and peak winter and summer base flows can vary by several orders of magnitude.

Extensive portions of the mainstems of all four major watersheds in the Monte Arido Highlands BPG region exhibit intermittent flows (with isolated pools) in summer because of a combination of strong seasonal variation in rainfall and anthropogenic factors.

8.2 LAND USE

Table 8-1 summarizes land use and population density in Monte Arido Highlands BPG region. The coastal terrace and floodplains of these watersheds receive the most intensive land use. The interiors are largely uninhabited and include several federally-designated wilderness areas within the Los Padres National Forest: San Rafael, Dick Smith, Matilija, Chumash, and Sespe. Additionally, there are two federally-designated Wild and Scenic rivers within the Los Padres National Forest: the Sisquoc River (Wild) in the Santa Maria River watershed, and Sespe Creek (Wild and Scenic) in the Santa Clara River watershed. Human population density increases steadily to the south, and averages about 129 persons per square mile over the BPG region. The Santa Maria River watershed has the lowest population density (66 persons/square mile), while the Santa Clara River watershed, which extends into northeastern Los Angeles County, has the highest population density (216 persons/square mile).

In most of these watersheds, the first land-use change was livestock ranching and dry farming, followed by irrigated row-crop agriculture. Urbanization followed this trend on the coastal plain, with current coastal population centers at Santa Maria, Lompoc, Buellton, Ventura, and Oxnard. More recently (decades ago), interior portions of the floodplain of the Santa Clara River that were converted to agriculture (primarily orchards), have experience strong urban growth

Table 8-1. Physical and Land-Use Characteristics of Watersheds in the Monte Arido Highlands 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]
Santa Maria River**	1,187,491	1,855	2,941	17.2	123,043	49%	10%	3%	87%
Santa Ynez River	576,717	901	1,543	18.3	74,900	39%	7%	3%	90%
Ventura River	144,967	227	409	18.8	44,550	48%	6%	9%	85%
Santa Clara River	1,040,223	1,625	2,485	16.7	350,363	54%	6%	7%	87%
TOTAL or AVERAGE	**2,949,398**	**4,608**	**7,378**	**17.7**	**592,856**	**48%**	**7%**	**6%**	**87%**

[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 2000 block data (migrated), 2003
[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 only; does not include State or County Parks or Military Reservations (from: http://old.casil.ucdavis.edu/casil/gis.ca.gov/teale/govtowna/)*
*** The Santa Maria River watershed includes the Cuyama River and Sisquoc River sub-watersheds.*

and now include population centers at Santa Paula, Fillmore, and, most recently, the Santa Clarita-Castaic-Newhall area in Los Angeles County. The upper watersheds throughout this region are in the Los Padres and Angeles national forests; the coastal and middle watersheds are mostly privately owned. Semi-developed rural land, used for livestock ranching and orchard production covers extensive portions of the coastal and middle portions of these watersheds.

Agricultural uses (orchard production, row crops, and livestock ranching), are important land uses that directly or indirectly impact watershed processes throughout these watersheds. Particularly in the lower Santa Maria, Santa Ynez, and Santa Clara River watersheds, transverse broad coastal watersheds or plains have mostly been converted to agriculture. The Santa Ynez River and the Ventura River watersheds have been transformed by a series of dams constructed to serve municipal water needs for the cities of Goleta, Santa Barbara, Montecito, Summerland, Carpinteria, and Ventura. A major diversion on the lower mainstem and three large dams in the upper watershed on Piru and Castaic creeks has similarly affected habitat and accessibility for anadromous *O. mykiss* in the Santa Clara River drainage. Municipal and agricultural water sources also include numerous groundwater wells located throughout the floodplains of these watersheds.

8.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for the mainstems of the four major rivers and for eight sub-watersheds in the Monte Arido Highlands BPG region. The mainstem and major tributaries of most of the drainages in this BPG region offer fair to poor habitat conditions for anadromous *O. mykiss*. Some tributaries to the Santa Maria River (*i.e.,* Sisquoc River), Ventura River (*i.e.,* Matilija Creek), and the Santa Clara River (*i.e.,* Sespe Creek) afford better habitat quality. Indicator ratings for the watersheds were typically downgraded during our threats assessment due to the presence of fish-passage barriers (see below). Good-quality to excellent-quality habitat is generally found in the upper watersheds above these barriers, particularly in the Sisquoc River, Matilija Creek mainstem, North Fork Matilija Creek, San Antonio Creek, Santa Paula Creek, and Sespe Creek drainages. Sespe Creek probably supports the highest-quality and most extensive spawning and rearing habitat for anadromous *O. mykiss* in this BPG region, but is frequently isolated from the estuary and ocean by water management activities elsewhere in the watershed that reduce or eliminate surface flows along extensive reaches of the mainstem. Several photographs of the Monte Arido Highlands BPG region are provided in Figure 8-2.

Twitchell Dam on the Cuyama River is located near the Sisquoc River confluence and blocks passage to the very large Cuyama River watershed, including several tributaries (*e.g.,* Pine Creek). Surface flows in the Cuyama River disappear for most of the year because of groundwater pumping throughout the arid Cuyama Valley to water row crops that have been extensively planted on the floodplain. Access to the equally large Sisquoc River watershed for anadromous *O. mykiss* is severely limited because Twitchell Dam is managed for aquifer recharge in the Santa Maria Valley with the aim of minimizing surface flows to the ocean. Consequently, the Santa Maria River, which is the access corridor for both the Cuyama and Sisquoc rivers, is dry most of the year in most years.

Figure 8-2. Photographs of Monte Arido BPG region.

Santa Ynez River

Santa Maria River

Ventura River

Santa Clara River

Sespe Creek – Santa Clara River Tributary

Santa Ana Creek – Ventura River Tributary

Twitchell Dam

Bradbury Dam

Matilija Dam

Santa Felicia Dam

Bradbury Dam, Gibraltar Dam, and Juncal Dam on the middle and upper mainstem of the Santa Ynez River and the Mono Debris Watershed Dam on Mono Creek, and upper tributary the Santa Ynez River block access to at least 70% of the highest quality spawning and rearing habitat within this watershed. Union Pacific Railroad tracks traverse the mainstem of each of the rivers and streams near their mouths, which has damaged estuarine habitat and created additional passage impediments for anadromous *O. mykiss*.

Matilija Dam and Casitas Dam on the mainstem of Matilija Creek and Coyote Creek, respectively, have eliminated access to 90% of the highest quality spawning habitat in the Ventura River watershed. The planning and implementation of a project to remove Matilija Dam is underway. The Robles Diversion Dam on the mainstem has recently been retrofitted with a fish-passage facility, but diversions and operational limitations still limit fish passage below and above the facilities.

Santa Felicia Dam and Pyramid Dam on Piru Creek effectively block fish passage to spawning and rearing habitat in this major tributary of the Santa Clara River; additionally, the operation of these two dams restricts access to all of the major tributaries below Piru Creek by the reduction of surface flows (including magnitude and duration) in the mainstem of the Santa Clara River and to the estuary; fish passage is further impacted by the operation of Bouquet Dam on Castaic Creek, an upper tributary of the Santa Clara River.

Agricultural and urban development has severely constrained floodplain connectivity on sections the floodplains of the Santa Maria River, lower Sisquoc River, Santa Ynez River, Ventura River, Coyote Creek, San Antonio Creek, Santa Clara River, and lower Sespe Creek. Levees, channelization, and other flood control structures and activities, including related flood control activities (levee and vegetation management, *etc.*), constrict the floodplain and alter natural channel morphology (and affect sediment transport processes), which limit instream habitat diversity and riparian corridor structure.

Non-native species are a widespread threat source in the Monte Arido Highlands BPG. Most or all of the reservoirs formed by these dams support sport fishing that has intentionally or accidentally introduced non-native fishes that prey on or compete with *O. mykiss*. These species have moved out of the reservoirs into the mainstem and tributaries, including reaches above and below the dams and established reproducing populations (*e.g.*, crayfish, largemouth bass, sunfish, catfish, carp, western mosquitofish, bullfrogs, *etc.*). Bullfrogs and carp are common throughout the mainstem of the Santa Ynez and Ventura rivers. The African clawed frog (*Xenopus laevis*), a significant predator of native amphibians and fish, infests much of the mainstem of the Santa Clara River from the estuary upstream to Fillmore, including large tributaries such as Santa Paula Creek and Hopper Canyon Creek. Additionally, the highly invasive non-native giant reed (*Arundo donax*) has displaced large areas of native riparian vegetation in the Ventura River and Santa Clara River watersheds, and continues to spread to other areas.

Because of the chaparral dominated upland areas, fire is an important factor in slope erosion and sediment inputs to watersheds throughout this region. Increased fire frequency can increase slope erosion and sediment input to streams, resulting in long-term changes to substrate texture

and embeddedness, water quality (*e.g.*, turbidity), and water temperature (loss of riparian canopy cover). The Sisquoc River, North Fork Matilija Creek, and Piru Creek watersheds were identified as potentially severely threatened by mass wasting of slopes and loss of riparian canopy cover due to fires that occurred in 2006 and 2007 that covered most of their watersheds, but substantial portions of each of these watersheds have burned in the past 50 years. All of the watersheds in this BPG region are naturally susceptible to wildfires, but have experienced larger and more intense fires because of the development and management of these watersheds.

The estuaries at the mouth of the Santa Maria River and Santa Ynez River are relatively physically intact, retaining 81% to 94% of their historic size, respectively, although both are impacted by agricultural and urban effluent discharge. The Ventura River estuary has been reduced by approximately 68% due to urban and agricultural encroachment (*e.g.*, Ventura County Fairgrounds, Emma Wood State Beach, Union Pacific Railroad bridge, Highway 101 bridge). The Santa Clara River estuary has been reduced by approximately 85% due to agricultural and oil development, levee construction, and the development of the Ventura Marina and McGrath State Beach. Because estuaries are the gateway used by both immigrating adults and emigrating juveniles moving between the marine and freshwater environments, estuarine loss affects anadromous *O. mykiss* throughout the entire watershed. The remaining estuarine habitats are subject to degradation from urban, agricultural, and/or recreational development and loss of freshwater inflows. Surface flows diverted from the mainstem for urban and agricultural use adversely affect both water quality and the seasonal breaching pattern of the sandbar at the mouth of the estuary.

Despite widespread and varied habitat degradation to the coastal and middle mainstems of all four major river systems, native rainbow trout populations still inhabit the relatively high-quality habitat upstream of the dams in this region, and small numbers of steelhead attempt to enter and spawn in each of the watersheds of the Monte Arido Highlands BPG region when flow conditions are suitable.

8.4 THREATS AND THREAT SOURCES

Varying numbers and intensities of habitat impairments (sources of threats) were identified in the CAP Workbooks analyses, ranging from seven sources in the North Fork Matilija Creek watershed to 21 in the Cuyama River watershed. "High" and "Very High" sources of threats involving fish-passage barriers created by dams and lack of surface flows caused by groundwater extraction or surface flow diversions disproportionately impact habitat conditions in all of the watersheds in this BPG region. For example, Sespe Creek, which is relatively undisturbed and supports some of the best spawning habitat in the BPG region, is severely threatened by urban development occurring downstream along the mainstem of the Santa Clara River watershed. This development includes water management activities that interrupt the connection between this sub-watershed, the mainstem, estuary, and ocean.

Fifteen anthropogenic activities ranked as the top five sources of stress to steelhead within each watershed in the Monte Arido BPG and are strongly associated with urban and agricultural development and recreation (Table 8-2).

Table 8-2. Threat source rankings in each watershed in the Monte Arido Highlands BPG (see CAP Workbooks for details).

Monte Arido Highlands BPG Component Watersheds (north to south)													
Threat Sources	Santa Maria River	Cuyama River	Sisquoc River	Santa Ynez River	Ventura River	Coyote Creek	Matilija Creek mainstem	North Fork Matilija Creek	San Antonio Creek	Santa Clara River*	Santa Paula Creek	Sespe Creek	Piru Creek
Dams and Surface Water Diversions													
Groundwater Extraction													
Agricultural Development													
Urban Development													
Recreational Facilities													
Non-Native Species													
Levees and Channelization													
Flood Control													
Wildfires													
Mining and Quarrying													
Roads													
Urban Effluents													
Agricultural Effluents													
Other Passage Barriers													

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

**Wildfires were not identified during the CAP Workbook analyses as one of the top five threats in several of these watersheds, but recent fires in coastal watershed since 2007 could result in significant habitats impacts.*

8.5 SUMMARY

Dams, surface water diversions (including groundwater extraction) driven by agricultural and urban development on the major rivers of the Monte Arido Highlands BPG region (Santa Maria River, Santa Ynez River, Ventura River, and Santa Clara River) have had the most severe impacts on the steelhead populations in this BPG region, cutting off access to upstream spawning and rearing habitats and reducing both the magnitude and duration of flows, as well as altering the timing of flows necessary for immigration of adults and emigration of juveniles. Table 8-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG.

Table 8-3. Critical recovery actions for Core 1 populations within the Monte Arido Highlands BPG.

POPULATION	CRITICAL RECOVERY ACTION
Santa Maria River	Implement operating criteria to ensure the pattern and magnitude of water releases from Twitchell Dam comport with the natural or pre-dam pattern and magnitude of streamflow. Physically modify Twitchell Dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary restore estuarine and freshwater rearing habitats.
Santa Ynez River	Implement operating criteria to ensure the pattern and magnitude of water releases from Bradbury, Gibraltar, and Juncal dams comport with the natural or pre-dam pattern and magnitude of streamflow. Physically modify Bradbury, Gibraltar, and Juncal dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary restore estuarine and freshwater rearing habitats.
Ventura River	Implement operating criteria to ensure the pattern and magnitude of water releases from Casitas, Matilija, and Robles Diversion dams comport with the natural or pre-dam pattern and magnitude of streamflow. Physically modify Casitas, Matilija, and Robles Diversion dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary restore estuarine and freshwater rearing habitats.
Santa Clara River	Implement operating criteria to ensure the pattern and magnitude of water releases from Vern Freeman Diversion, Santa Felicia, Pyramid, and Castaic dams comport with the natural or pre-dam pattern and magnitude of streamflow. Physically modify Vern Freeman Diversion, Harvey Diversion, Santa Felicia, and Pyramid dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary restore estuarine and freshwater rearing habitats.

Restoring conditions for steelhead passage, spawning, and/or rearing in these watersheds will require multiple, long-term, measures related to water management, recreation, and fish passage past large dams. Impediments to fish passage stemming from the construction and operation of dams and groundwater extraction, modification of channel morphology and adjacent to riparian habitats through flood control, instream activities such as sand gravel mining, and loss of estuarine functions caused by filling and point and non-point water discharges from agriculture an other anthropogenic activities should be further evaluated and addressed.

The threats sources discussed in this section should be the focus of a variety of recovery actions to address specific stresses to anadromous *O. mykiss* viability. Spatial and temporal data acquired on specific indicators associated with threat sources or stresses, such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigation in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Monte Arido Highlands BPG. Tables 8-4 through 8-7 below rank and describe proposed recovery actions for each sub-watershed in the Monte Arido BPG including the estimated cost for implementing such actions over the first five fiscal years.

Table 8-4. Southern California Steelhead DPS Recovery Action Matrix for Santa Maria River Sub-Watersheds (Monte Arido Highlands BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
Santa Maria Mainstem											
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	1B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	1B						
	Develop and implement a restoration and management plan for the Santa Maria River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review development and management plans for all recreational areas (e.g., Dunes Center/Rancho Guadalupe Dunes Preserve) to provide for the restoration and protection of the Santa Maria River Watershed, estuary and riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	2B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	2B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Santa Maria Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop and implement a plan to remove or physically modify all fish passage barriers identified in the Santa Maria River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats (see Steelhead Migration Assessment and Recovery Opportunities for the Sisquoc River, California 2003)		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	3B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Relocate agricultural development		Agricultural Development	1, 4							
Cuyama River											
	Physically modify Twitchell Dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Conduct hydrological analysis and implement operating criteria to ensure the pattern and magnitude of releases from Twitchell Dam comport with the natural pre-dam pattern and magnitude of streamflow		Dams and Surface Water Diversions	1, 3, 4	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Implement operating criteria to ensure the pattern and magnitude of water releases from Twitchell Dam comport with the natural or pre-dam pattern and magnitude of streamflow		Dams and Surface Water Diversions	1, 3, 4	1B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop and implement a plan to remove or physically modify all fish passage barriers identified in the Santa Maria River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats (see Steelhead Migration Assessment and Recovery Opportunities for the Sisquoc River, California 2003)		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	3B						
	Relocate agricultural development		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Develop and implement a public educational program		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop, adopt, and implement recreational land-use planning policies		Recreational Facilities	1, 2, 4	3B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Cuyama Community Sanitation District Treatment Facility)		Urban Effluents	1, 4	3B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
Sisquoc River											
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Relocate agricultural development		Agricultural Development	1, 4	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop, adopt, and implement recreational land-use planning policies		Recreational Facilities	1, 2, 4	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to remove or modify all fish passage barriers identified in the Santa Maria River Watershed (see Steelhead Migration Assessment and Recovery Opportunities for the Sisquoc River, California 2003)		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4							

Table 8-5. Southern California Steelhead DPS Recovery Action Matrix for Santa Ynez River Watershed (Monte Arido Highlands BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify Bradbury, Gibraltar, and Juncal dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	1B						
	Implement operating criteria to ensure the pattern and magnitude of water releases from Bradbury, Gibraltar, and Juncal dams comport with the natural or pre-dam pattern and magnitude of streamflow		Dams and Surface Water Diversions	1, 3, 4	1B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	1B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify the Vandenberg Air Force Base Integrated Natural Resources Management Plan		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Conduct feasibility study to assess the potential for restoration of the Santa Ynez River estuary"	VAFB	Other Recovery Actions								
	Develop and implement an estuary restoration and management plan for the Santa Ynez estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review development and management plans of the Santa Ynez River Estuary		Recreational Facilities	1, 2, 4	1B						
	Develop and implement an integrated wildland fire and hazardous fuels management plan, including monitoring,		Wildfires	1, 4, 5	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	remediation and adaptive management, to reduce potentially catastrophic wildland fire effects to steelhead and their habitat and preserve natural ecosystem processes (including sediment deposition)										
	Develop and implement a plan to remove or physically modify all fish passage barriers identified in the Santa Ynez River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats (see Steelhead Migration Assessment and Recovery Opportunities for the Santa Ynez River, California 2003; and Lower Santa Ynez River Fish Management Plan, 2000)		Culverts and Road Crossings (Passage Barriers)	1, 4	2A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	2B						
	Relocate agricultural development		Agricultural Development	1, 4	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near		Levees and Channelization	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	levees										
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Lompoc Regional Wastewater Treatment Facility and Santa Ynez Band Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						

Table 8-6. Southern California Steelhead DPS Recovery Action Matrix for Ventura River Sub-Watersheds (Monte Arido Highlands BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
Mainstem Ventura River											
	Physically modify Robles Diversion dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	1A						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	1A						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	1B						
	Develop and implement operating criteria to ensure the pattern and magnitude of water releases from Casitas, Matilija, and Robles Diversion and Foster Park dams comport with the natural or pre-dam pattern and magnitude of streamflow		Dams and Surface Water Diversions	1, 3, 4	1B						
	Develop and implement a restoration and management plan for the Ventura River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review development and management plans for all recreational areas (e.g., Emma Wood State Beach, City of Ventura Seaside Wilderness Park) to provide for the restoration and protection of the Ventura River Watershed, estuary and riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	1B						
	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		Wildfires	1, 4, 5	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	(including sediment deposition)										
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	2B						
	Relocate agricultural development		Agricultural Development	1, 4	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Ojai Valley Sanitary District Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop, adopt, and implement recreational land-use planning policies		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Physically modify or remove all passage barriers in the Ventura River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	3B						
Coyote Creek											
	Physically modify Casitas Dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						
	Develop and implement operating criteria to ensure the pattern and magnitude of water releases from Casitas Dam comport with the natural or pre-dam pattern and magnitude of streamflow		Dams and Surface Water Diversions	1, 3, 4	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Physically modify or remove all fish passage barriers identified in the Coyote Creek Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	2A						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1,4	2B						
	Relocate agricultural development		Agricultural Development	1,4	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1,4	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	2B						
	Review development and management plans for all County recreational areas (e.g., E.P. Foster Memorial Park) to provide for the restoration and protection of the Coyote Creek and riparian/floodplain areas		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Fillmore Wastewater Treatment Facility, Santa Paula Wastewater Treatment Facility, and Ventura Wastewater Treatment Facility)		Urban Effluents	1, 4	3B						
Matilija Creek											
	Physically remove Matilija Dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	1B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	1B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review development and management plans for County recreational areas (e.g., Matilija Reservoir) to provide specific provisions for the restoration and protection of the Matilija Creek riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review, assess and modify, if necessary, residential wastewater septic treatment facilities		Urban Effluents	1, 4	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop, adopt, and implement recreational land-use planning policies		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Physically modify or remove all fish passage barriers identified in the Matilija Creek Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1.4	3B						
	Retrofit storm drains in developed areas		Urban Development	1,4	3B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5							
North Fork Matilija Creek											

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify or remove all fish passage barriers identified in the North Fork Matilija Creek Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a plan to remove and maintain quarry and landslide debris from the channel		Mining and Quarrying	1, 4, 5	1A						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Relocate livestock grazing and water sources		Agricultural Development	1,4	2B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop, adopt, and implement recreational land-use planning policies		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Conduct hydrological analysis		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1.4	3B						
	Retrofit storm drains in developed areas		Urban Development	1,4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4							

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
San Antonio Creek											
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	1A						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	1B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Physically modify or remove all fish passage barriers identified in the San Antonio Creek Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	2A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1,4	2B						
	Relocate agricultural development		Agricultural Development	1,4	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1,4	2B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	2B						
	Review development and management plans for County recreational areas (e.g., e.g., Camp Comfort) to provide specific provisions for the restoration and protection of the San Antonio Creek riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1.4	2B						
	Retrofit storm drains in developed areas		Urban Development	1,4	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop, adopt, and implement recreational land-use planning policies		Recreational Facilities	1, 2, 3, 4, 5	2B						

Table 8-7. Southern California Steelhead DPS Recovery Action Matrix for Santa Clara River Sub-Watersheds (Monte Arido Highlands BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
Mainstem Santa Clara											
	Physically modify Vern Freeman Diversion Dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement operating criteria to ensure the pattern and magnitude of water releases from Vern Freeman Diversion Dam comport with the natural or pre-dam pattern and magnitude of streamflow		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	1B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	1B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	1B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	1B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	1B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	1B						
	Develop and implement a restoration and management plan for the Santa Clara River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review development and management plans for McGrath State Beach to provide for the restoration and protection of the Santa Clara River Watershed, estuary and riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	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 deposition)		Wildfires	1, 4, 5	1B						
	Physically modify or remove all fish passage barriers in the Santa Clara River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats (see Santa Clara River Steelhead Trout Assessment and Recovery Opportunities, 2005)		Culverts and Road Crossings (Passage Barriers)	1, 4	2A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4,	2B						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a public educational program		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review development and management plans for all County and City recreational areas (e.g., Olivas Park Golf Course, Buena Ventura Golf Course, River Ridge Golf Club) to provide for the restoration and protection of the Santa Clara River Watershed, estuary and riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	2B						
	Relocate agricultural development		Agricultural Development	1, 4,	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop, adopt, and implement recreational land-use planning policies		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
Santa Paula Creek											
	Physically modify Harvey Diversion Dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Implement operating criteria to ensure the pattern and magnitude of water releases from Harvey Diversion Dam comport with the natural or pre-dam pattern and magnitude of streamflow		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	1B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	1B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	1B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1, 2, 4	2B						
	Review development and management plans for all County and City recreational areas (e.g., Steckel Park) to provide for the restoration and protection of the Santa Clara River Watershed, estuary and riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Relocate agricultural development		Agricultural Development	1, 4,	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Physically modify or remove all fish passage barriers in the Santa Clara River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats (see Santa Clara River Steelhead Trout Assessment and Recovery Opportunities, 2005)		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
Sespe Creek											
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	1B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	1B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	2B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1, 2, 3, 4, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review development and management plans for U.S. Forest Service Los Padres National Forest to provide for the restoration and protection of the Santa Clara River Watershed, estuary and riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Relocate agricultural development		Agricultural Development	1, 4,	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Physically modify or remove all fish passage barriers in the Santa Clara River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats (see Santa Clara River Steelhead Trout Assessment and Recovery Opportunities, 2005)		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Cuyama Community Sanitation District Treatment Facility)		Urban Effluents	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4							
	Retrofit storm drains in developed areas		Urban Development	1, 4							
Piru Creek											
	Physically modify Santa Felicia and Pyramid dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement operating criteria to ensure the pattern and magnitude of water releases from Santa Felicia and Pyramid dams comport with the natural or pre-dam pattern and magnitude of streamflow		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	1A						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	1A						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	1B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4, 5	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement land-use planning policies and standards		Agricultural Development	1, 4	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program		Recreational Facilities	1, 2, 4	2B						
	Review development and management plans for City, United Water Conservation District and U.S. Forest Service Los Padres National Forest recreational areas to provide for the restoration and protection of the Santa Clara River Watershed, estuary and riparian/floodplain area		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Review California Regional Water Quality Control Board Central Coast Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Relocate agricultural development		Agricultural Development	1, 4,	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review U.S. Forest Service Los Padres National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Physically modify or remove all fish passage barriers in the Santa Clara River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats (see Santa Clara River Steelhead Trout Assessment and Recovery Opportunities, 2005)		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						

9. Conception 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, 2007

9.1 LOCATION AND PHYSICAL CHARACTERISTICS

The Conception Coast BPG region encompasses eight small, coastal watersheds that drain a 50-mile long stretch of the south-facing slopes of the Santa Ynez Mountains in southern Santa Barbara County and extreme southwestern Ventura County (Figure 9-1). The Santa Ynez Mountains are an east-west trending spur of the Transverse Range that creates some of the steepest watersheds in any of the five BPG regions in the SCS Recovery Planning Area. Peak elevations reach 4,300 feet within a few miles of the Pacific Ocean. These watersheds are relatively homogeneous in slope, aspect, and size, with steep upper watersheds and lower watersheds that cut across a relatively narrow coastal terrace.

Stream lengths are relatively short in this BPG region. The Gaviota Creek watershed penetrates the furthest inland (about seven miles). Goleta Slough, the largest estuary in this BPG region, is formed by the confluence of several sub-watersheds: Tecolotito Creek, Los Carneros Creek, San Pedro Creek, Las Vegas Creek, Maria Ygnacio Creek, San Jose Creek, and Atascadero Creek. Of these, the latter three watersheds were evaluated using the CAP analyses. The second largest estuary in this BPG region, Carpinteria Slough, is formed by a synclinal Watershed fed by Santa Monica Creek and several minor drainages that are not included in the watersheds covered in the Conception Coast BPG region. Precipitation in this region increases strongly with increasing elevation. Rainfall amounts in the upper watersheds can be five to six times higher than on the coastal terrace of these watersheds during the same storm event, and the steep topography creates extremely "flashy" flows.

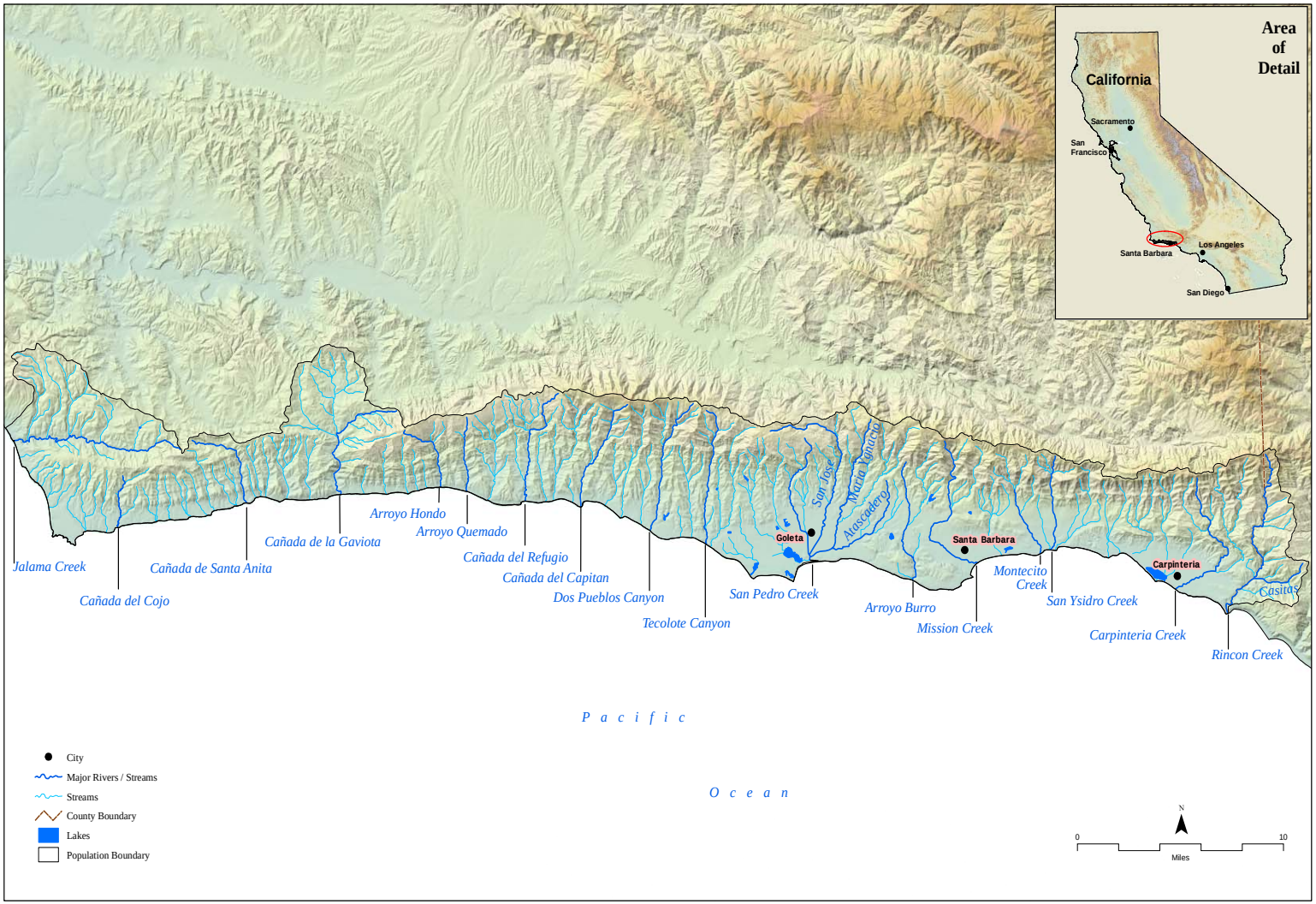

Figure 9-1. The Conception Coast BPG region. Ten steelhead populations/watersheds were analyzed in this region.

9.2 LAND USE

Table 9-1 summarizes land use and population density in this region. The coastal terrace and middle portions of these watersheds receive the most intensive land use. Human population density varies widely between the component watersheds, averaging about 605 persons per square mile over the entire BPG region. The western half of the BPG region has very low population density (1 to 59 persons/square mile), while the Goleta Slough and Mission Creek watersheds average 1,201 and 3,491 persons per square mile, respectively (see Table 9-1 for additional comparisons).

In most of the watersheds in this BPG region, the first land use change was livestock ranching and dry farming, followed by irrigated row-crop agriculture, particularly orchard crops such as avocados, lemons, and walnuts. Most recently, steeper slopes in the middle reaches of some watersheds have been developed with avocado and other orchard crops. Urbanization followed this trend on the coastal plain in the eastern half of this BPG region then moved up into the more mountainous portions of the watersheds as cities grew in size. The upper watersheds throughout this region are located within the Los Padres National Forest; whereas the coastal and middle watersheds are mostly privately owned. Semi-developed rural land and orchards cover extensive portions of the coastal and middle portions of the western watersheds. Most of the Arroyo Hondo watershed has recently been put under a conservation easement and is managed by the Land Trust of Santa Barbara County.

A number of coastal areas in this region have been developed as County and State Parks, including Jalama Beach County Park (Jalama Creek), Gaviota State Beach (Gaviota Creek), Refugio State Beach (Refugio Creek), El Capitan State Beach (El Capitan Creek), Goleta Beach County Park (mouth of Goleta Slough), Arroyo Burro Beach County Park (Arroyo Burro Creek), City of Santa Barbara beaches (east and west of mouth of Mission Creek), Carpinteria State Beach (Carpinteria Creek), and Rincon Beach County Park (Rincon Creek). Each of these parks is located around the mouth of these drainages, including the estuary.

Agriculture (orchard cultivation and livestock ranching), are important land uses that directly or indirectly impact watershed processes throughout these watersheds. Most of the municipal water for Goleta, Santa Barbara, Montecito, Summerland, and Carpinteria is supplied by reservoirs on the middle and upper mainstem of the Santa Ynez River on the north side of the Santa Ynez Range. This municipal water source is supplemented by groundwater wells located throughout the coastal terrace. The ranches that support irrigated orchard crops in these watersheds also depend heavily on groundwater as their source for agricultural water. Some large ranches have diversions and dams on their property to create reservoirs for agricultural use (*e.g.*, Glen Annie Canyon, an unnamed tributary of Dos Pueblos Creek, and Gato Creek).

Some of these reservoirs support small populations of bullfrogs and non-native predatory fish (*e.g.*, Dos Pueblos Creek tributary reservoir), but the majority of the drainages in these watersheds are relatively free from these predators. Non-native crayfish and western mosquitofish, which may prey on *O. mykiss* eggs, occur in many urbanized drainages. Tecolotito Creek in the Goleta Slough watershed supports a reproducing population of African clawed frogs (*Xenopus laevis*), which may be a predator on certain *O. mykiss* life-stages.

Table 9-1. Physical and Land-Use Characteristics of Watersheds in the Conception Coast BPG region.

PHYSICAL CHARACTERISTICS						LAND USE			
WATERSHEDS (west to east)	**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]
Jalama Creek	15800	25	45	17.4	59			< 1%	
Canada de Santa Anita	2067	3	5	17.4	16			< 1%	
Gaviota Creek	12912	20	39	17.5	40			1%	
Arroyo Hondo	2796	4	6	17.8	1			< 1%	
Tecolote Creek	3726	6	11	19	339			18%	
Goleta Slough**	30410	48	92	19.2	57,664			16%	
Mission Creek	7760	12	16	19.6	41,890			3%	
Montecito Creek	3970	6	11	19.5	2,453			< 1%	
Carpinteria Creek	10712	17	25	19.8	3,493			20%	
Rincon Creek	9422	15	25	19.3	324			23%	
TOTAL or AVERAGE	**213099**	**333**	**560*** **	**18.6**	**201,459*** **		**16%**	**8%**	**74%**

[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 2000 block data (migrated), 2003
[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 only; does not include State or County Parks or Military Reservations (from: http://old.casil.ucdavis.edu/casil/gis.ca.gov/teale/govtowna/)*
** Goleta Slough" includes analyses only for San Jose, San Pedro, Maria Ygnacio, and Atascadero creeks.
**** Total for entire BPG region, not component watersheds.*

9.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for ten watersheds in the Conception Coast BPG region. In general, instream, riparian, and floodplain conditions for steelhead in these watersheds offer fair to good habitat conditions for anadromous *O. mykiss*, although conditions vary widely within and between watersheds, depending on land uses. The upper watersheds consistently support good to excellent quality spawning and rearing habitat; however, conditions in each of these watersheds deteriorate downstream on the coastal plain. Highway 101 and the Union Pacific Railroad tracks traverse the mainstem of each of these watersheds at or in close proximity to their mouths, which has damaged estuarine habitat and created passage impediments for anadromous *O. mykiss*. Agricultural activities, such as groundwater extraction, have reduced surface flows and degraded habitat conditions in the lower and middle portions of these watersheds. Urban development dominates the lower reaches of the Goleta Slough, Mission Creek, Montecito Creek, and Carpinteria Creek watersheds. Several photographs of the Conception Coast BPG region are provided in Figure 9-2.

Most of these watersheds also exhibit high road densities. The Arroyo Hondo watershed provides the least disturbed conditions for steelhead in this BPG because of low-intensity land use and its inclusion in a natural reserve system managed by the Land Trust of Santa Barbara County. The Goleta Slough watershed (San Jose, San Pedro, Maria Ygnacio, and Atascadero creeks) and the Mission Creek and Rincon Creek watersheds exhibit the least favorable conditions; however, their upper watersheds sustain reproducing populations of non-anadromous *O. mykiss* and occasionally anadromous forms despite urbanization, channelization, channel maintenance, and other urban land uses throughout their lower reaches.

The terrain of the Santa Ynez Mountains results in development on steep slopes, often accompanied by road cuts to provide access, thus affecting watershed processes such as erosion and sedimentation. Development has also occurred along narrow riparian corridors, which encourages bank stabilization, levee construction, and other flood control activities that physically constrain the ability of streams to maintain natural channel morphology and riparian vegetation.

Estuarine habitats at the mouths of these watersheds in this BPG region have been reduced in size by 70 percent to 95 percent by the development of roads and railroads, urbanization, and development of recreational facilities. Historically, these estuaries were relatively small with two notable exceptions. Goleta Slough, formed by the confluence of several watersheds, and the estuary associated with Mission Creek, comprised extensive wetland habitats in this BPG region, encompassing thousands of acres. The remaining estuarine habitats are subject to constriction and isolation by development, surface runoff from roads and other impervious surfaces, as well as a reduction in the amount and quality of surface flows resulting from groundwater extraction.

Figure 9-2. Photographs of Conception Coast BPG region.

Santa Ynez Mountains

Rincon Creek

Mission Creek

Mission Creek Estuary

9.4 THREATS AND THREAT SOURCES

Varying numbers and intensity of habitat impairments (sources of threats) were identified in the CAP Workbooks analyses, ranging from 10 in the Gaviota Creek and Arroyo Hondo watersheds to 17 in the Rincon Creek watershed. "Severe" and "Very Severe" sources of threats exist in all of the watersheds in this BPG region, but the Arroyo Hondo watershed has the least number and severity of threats for anadromous *O. mykiss*. Threat sources are concentrated in the middle and lower portions of the watersheds and are associated with urban and agricultural development. The number and severity of threats generally diminishes in the upper, undeveloped portion of these watersheds. Anadromous and non-anadromous *O. mykiss* spawn in the upper reaches of most, and even in the degraded lower reaches of some of these drainages, such as Maria Ygnacio, Mission, and Carpinteria creeks.

Thirteen anthropogenic activities, all strongly associated with urban and agricultural development, ranked as the top five sources of stress to *O. mykiss* in the Conception Coast BPG watersheds (Table 9-2). Road density, including roads in close proximity to stream riparian zones, and passage barriers associated with transportation corridors, consistently ranked as "Severe" to "Very Severe" threat sources. Proximal stressors associated with increased road density, especially roads near the drainage, include increased non-point pollution, sedimentation, substrate embeddedness, floodplain encroachment and constriction, channel incision, and loss of channel structural complexity.

Increased road density also leads to increased frequency of road crossings, culverts, and other structures that can form passage barriers, preventing anadromous *O. mykiss* from accessing spawning and rearing habitat. As previously stated, Highway 101 and the Union Pacific Railroad tracks cross the mainstem of each of these watersheds near their mouths, in most cases through culverts. Highway 101 and the railroad tracks typically crossed these drainages by filling streambeds with earthen berms and forcing streams to flow through culverts of varying lengths. In some cases, construction of these transportation corridors reduced the extent of estuarine habitat. The Highway 101 culvert on Rincon Creek and a number of other creeks is an impassable barrier preventing anadromous *O. mykiss* from reaching spawning and rearing habitat and isolating formerly anadromous populations in the upper watershed.

Groundwater extraction for municipal and agricultural use also is a pervasive threat source among these watersheds. Widespread pumping of groundwater routinely eliminates surface flows and de-waters pools in portions of most of these drainages. The magnitude of loss of surface flows and the severity of passage barriers is exacerbated during years of below-average precipitation. These effects negatively impact multiple *O. mykiss* life stages (*e.g.*, development of eggs, alevins, fry, and parr).

Increasing urbanization of the Tecolote Creek, Goleta Slough, Mission Creek, Montecito Creek, and Carpinteria Creek watersheds creates a number of threat sources ranging from increased road density to floodplain encroachment and the increased need for flood control structures, such as levees and channelization, and greater channel maintenance.

Five other threat sources are specific to one or two watersheds and have seriously degraded habitat conditions for steelhead there. For example, past quarrying activities in Rincon Creek have created a rock barrier that completely blocks upstream migration of anadromous *O. mykiss* and severely impedes downstream migration of resident non-anadromous *O. mykiss* above this barrier. Fire has recently burned much of the Gaviota Creek watershed and erosion of burned slopes in the watershed is a significant, though diminishing source of sediment. Gaviota State Beach campground was developed along the shores of the estuary at the mouth of the Gaviota Creek watershed and has affected the size of the estuary, degraded water quality, and created a severe passage impediment at a road crossing that provides access to Gaviota State Beach campground and Hollister Ranch. Jalama Creek and Canada de Santa Anita have dams or other severe passage impediments on their mainstems and tributaries.

9.5 SUMMARY

Culverts and road crossing (along with other fish passage barriers such as small dams) are widespread throughout the Conception Coast BPG region, cutting off or severely reducing access to upstream spawning and rearing habitats for anadromous *O. mykiss*. Groundwater extraction has significantly altered flow regimes, particularly in the lower stream reaches, and thus adversely affected both upstream and downstream fish passage and spawning and rearing opportunities. Levees and channelization associated with urban encroachment have restricted or eliminated riparian habitat, and urban and agricultural development (particularly on steep slopes) has altered run-off patterns and increased erosion and sedimentation, particularly in lower stream reaches. Table 9-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG.

Table 9-2. Threat source rankings in component watersheds in the Conception Coast BPG region (see CAP Workbooks for individual watersheds for details).

Threat Sources	Conception Coast BPG Component Watersheds (east to west)									
	Jalama Creek	Canada de Santa Anita	Gaviota Creek	Arroyo Hondo	Tecolote Creek	Goleta Slough*	Mission Creek	Monte-cito Creek	Carpinteria Creek	Rincon Creek
Roads										
Culverts & Crossings (passage barrier)										
Groundwater Extraction										
Levees and Channelization										
Urban Development										
Wildfires										
Recreational Facilities										
Non-Point Pollution										
Flood Control										
Mining and Quarrying										
Agricultural Development										
Dams and Surface Water Diversions										
Livestock Ranching										

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 several of these watersheds, but recent fires in coastal watershed sin 2007 could result in significant habitat impacts.*

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

POPULATION	CRITICAL RECOVERY ACTION
Mission Creek	Halt the unnatural dry-season reduction in the amount and extent of surface water to restore natural or pre-impact over-summering habitat characteristics and condition for steelhead. Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary restore estuarine and freshwater rearing habitats.
Carpinteria Creek	Halt the unnatural dry-season reduction in the amount and extent of surface water to restore natural or pre-impact over-summering habitat characteristics and condition for steelhead. Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary restore estuarine and freshwater rearing habitats.
Rincon Creek	Halt the unnatural dry-season reduction in the amount and extent of surface water to restore natural or pre-impact over-summering habitat characteristics and condition for steelhead. Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary restore estuarine and freshwater rearing habitats.

Restoring conditions for anadromous *O. mykiss* passage, spawning, and/or rearing in these watersheds will require multiple, long-term, measures related to water management, and barrier removal or improvements. Impediments to fish passage stemming from the construction and maintenance of roads and other transportation corridors, privately-owned dams and other passage barriers on some drainages, groundwater extraction, modification of channel morphology and adjacent riparian habitats for flood control, and other instream activities need to be further evaluated for this BPG. Additionally, the loss of estuarine functions caused by filling and pollution from point and non-point agricultural and other anthropogenic waste discharges need to be addressed further in this region.

The threat sources discussed in this section should be the focus of a variety of recovery actions to address specific stresses on anadromous *O. mykiss* viability. Spatial and temporal data acquired on specific indicators associated with threat sources or stresses such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Conception Coast. Tables 9-4 through 9-13 below rank and describe proposed recovery actions for each sub-watershed in the Conception Coast BPG including the estimated cost for implementing such actions over the first five fiscal years.

Table 9-4. Southern California Steelhead DPS Recovery Action Matrix for the Jalama Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a restoration and management plan for the Jalama Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						

Table 9-5. Southern California Steelhead DPS Recovery Action Matrix for the Canada de Santa Anita Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a plan to remove or reduce approach-fill for Union Pacific Railroad line and Hollister Ranch Road		Roads	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4, 5	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a restoration and management plan for the Santa Anita Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	3B						

Table 9-6. Southern California Steelhead DPS Recovery Action Matrix for the Gaviota Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Gaviota Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways. Re-route existing Gaviota State Beach/Hollister Ranch access road and replace existing road crossings with clear span bridge		Roads	1, 4	2B						
	Retrofit storm drains to filter runoff from roadways (i.e., highway 101)		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Develop and implement a riparian restoration plan that focuses on replacing artificial band stabilization structures wherever feasible		Urban Development	1, 4	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	3B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 3, 4, 5	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4, 5	3B						

Table 9-7. Southern California Steelhead DPS Recovery Action Matrix for the Arroyo Hondo Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Arroyo Hondo Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways.		Roads	1, 4	3B						
	Develop and implement a plan to remove or reduce approach-fill for Highway 1		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways (i.e., highway 101)		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4, 5	3B						

Table 9-8. Southern California Steelhead DPS Recovery Action Matrix for the Tecolote Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Tecolote Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1A						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	2B						
	Retrofit storm drains to filter runoff from roadways (i.e., highway 101)		Roads	1, 4	2B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4, 5	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways. Re-route existing Gaviota State Beach/Hollister Ranch access road and replace existing road crossings with clear span bridge		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,							

Table 9-9. Southern California Steelhead DPS Recovery Action Matrix for the Goleta Slough Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Goleta Slough Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	2B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to abandon artificial channel created for lower San Jose Creek		Levees and Channelization	1, 4	2B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						
	Retrofit storm drains to filter runoff from roadways (e.g., Highway 101, city and county streets)		Roads	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Develop and implement a riparian restoration plan throughout mainstem that focuses on replacing artificial bank stabilization structures wherever feasible		Urban Development	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Goleta Sanitary District Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						

Table 9-10. Southern California Steelhead DPS Recovery Action Matrix for the Mission Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Mission Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Retrofit storm drains to filter runoff from roadways (e.g., highway 101)		Roads	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., El Estero Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						

Table 9-11. Southern California Steelhead DPS Recovery Action Matrix for the Montecito Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	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 deposition)		Wildfires	1, 4, 5	1B						
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	2A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Develop and implement a plan to remove or reduce approach-fill for Union Pacific Railroad and Highway 101		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways (e.g., Highway 101, city and county streets)		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Develop and implement a riparian restoration plan that focuses on replacing artificial bank stabilization structures wherever feasible		Urban Development	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (El Estero Wastewater Treatment Facility)		Urban Effluents	1, 4	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						

Table 9-12. Southern California Steelhead DPS Recovery Action Matrix for the Carpinteria Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Carpinteria Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	2B						
	Relocate orchard and agricultural development and restore riparian zone		Agricultural Development	1, 4,	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	2B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						
	Develop and implement a plan to remove or reduce approach-fill for Union Pacific Railroad line and Highway 101		Roads	1, 4	2B						
	Retrofit storm drains to filter runoff from roadways (e.g., Highway 101, city and county streets)		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Develop and implement a riparian restoration plan throughout mainstem that focuses on replacing artificial bank stabilization structures wherever feasible		Urban Development	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Carpinteria Sanitary District Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5							

Table 9-13. Southern California Steelhead DPS Recovery Action Matrix for the Rincon Creek Watershed (Conception Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Rincon Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	2B						
	Relocate orchard and agricultural development and restore riparian zone		Agricultural Development	1, 4,	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	2B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						
	Develop and implement a plan to remove or reduce approach-fill for Union Pacific Railroad line and Highway 101		Roads	1, 4	2B						
	Retrofit storm drains to filter runoff from roadways (e.g., Highway 101, city and county streets)		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Develop and implement a riparian restoration plan throughout mainstem that focuses on replacing artificial bank stabilization structures wherever feasible		Urban Development	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Carpinteria Sanitary District Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Develop and implement a plan to remove and maintain quarry debris from the channel		Mining and Quarrying	1, 4, 5	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						

10. Santa Monica Mountains 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

10.1 LOCATION AND PHYSICAL CHARACTERISTICS

The Santa Monica Mountains BPG region consists of five coastal watersheds located in southern Ventura and western Los Angeles counties. These watersheds drain the east-west coastal Santa Monica Mountains. These mountains are composed of recently uplifted marine and volcanic formations that extend approximately 32 miles from the Oxnard Plain in the west to the Los Angeles Watershed in the east. With the exception of Malibu Creek, these watersheds are relatively small and do not extend inland beyond the Santa Monica Mountains. The watersheds, from west to east, are: Big Sycamore Canyon Creek, Arroyo Sequit, Malibu Creek, Las Flores Canyon Creek, and Topanga Canyon Creek (Figure 10-1). The Santa Monica Mountains BPG region is similar to the Conception Coast BPG region in that it is comprised of a series of short, nearly parallel streams that drain steep south- facing slopes, with an average elevation of less than 2,500 feet.

The annual seasonal rainfall in the watersheds of this BPG region is approximately 18 inches, although rainfall is lower along the coast and increases with increasing elevation in the upper reaches of the watersheds. Malibu Creek is the largest watershed of the five watersheds, encompassing approximately 110 square miles and, unlike other coastal streams in the Big Sur Coast and Conception Coast BPG regions, penetrates through a break in the Santa Monica Mountains to drain a portion of its north-facing slopes and the south-facing slopes of the Simi Hills. Calleguas Creek and the Los Angeles River drain the remainder of the northern slopes of the Santa Monica Mountains.

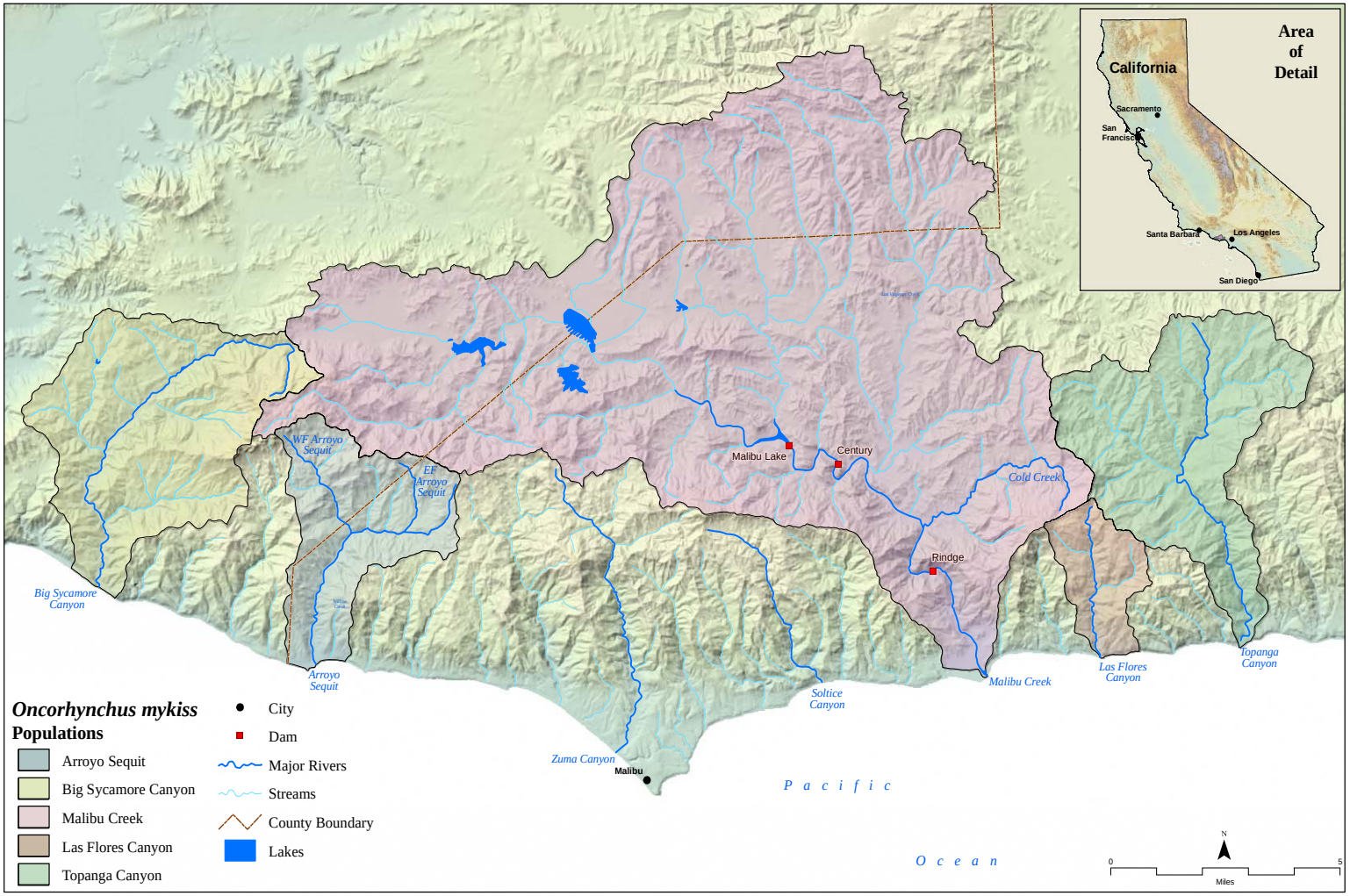

Figure 10-1. The Santa Monica Mountains BPG region. Five steelhead populations/watersheds were analyzed in this region.

10.2 LAND USE

Table 10-1 summarizes land use and population density in Santa Monica Mountains BPG region. A significant portion of the Santa Monica Mountains BPG region is undeveloped, and portions are publicly held as part of the Santa Monica Mountains National Recreation Area, seven state parks and beaches (Point Mugu State Park, Malibu Creek State Park, Leo Carrillo State Beach, Topanga State Park, R.H. Meyer Memorial State Beach, Dan Blocker State Beach, and Will Rogers State Park), and several local parks and beaches, including Zuma County Beach and Solstice Canyon Park. The large amount of public land and recreational facilities, coupled with the proximity to a large urban area (the Los Angeles Watershed) results in the watersheds here receiving very high recreational use.

Development within these watersheds is principally residential, with some commercial and recreational development concentrated near the mouths of several of the streams. The Malibu Creek and Topanga Canyon Creek watersheds support the highest human population densities. Watersheds in the western portion of the Santa Monica Mountains generally have less development and significantly more area in public ownership than watersheds in the eastern half of the range. Human population density and private land ownership increases in the Santa Monica Mountains from west to east with increasing proximity to the Los Angeles Watershed. Agricultural conversion of watershed lands is generally light throughout the BPG region.

10.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for the five major drainages in the Santa Monica Mountains BPG region. The mainstem and major tributaries of most of the drainages in this BPG region offer fair to good habitat conditions for anadromous *O. mykiss*. Existing habitat quality was rated as "Fair" in the Big Sycamore Canyon, Arroyo Sequit, Malibu Creek, and Las Flores Canyon watersheds, and "Good" in the Topanga Canyon Creek watershed. Existing conditions within the Topanga Canyon Creek watershed are relatively good, despite having the second highest human population density in this BPG region (Table 10-1). For example, Topanga Canyon Creek is characterized by perennial flows, high-quality instream and riparian conditions, an absence of non-native predators, and migration barriers, if present, are seasonally passable. Several photographs of the Santa Monica Mountains BPG region are provided in Figure 10-2.

Because of the proximity of the Santa Monica Mountains to large urban areas, there is significant pressure to develop and maintain recreational facilities. Each of the watersheds in the Santa Monica Mountains BPG region supports one or more coastal and inland campgrounds and other high-use recreational facilities. This is particularly the case in the Big Sycamore Creek, Arroyo Sequit, and Malibu Creek watersheds, where large portions of the watersheds are publicly owned. Recreational activities are recurring sources of direct and indirect threats to anadromous *O. mykiss* including: roadway stream crossings in and around campgrounds that pose physical barriers to upstream and/or downstream movement migration; introduction of non-native plants and animals; disturbance to stream banks and instream habitats, and even redds by foot traffic and off-road vehicles; loss of or disturbance to riparian corridors around campgrounds; and constriction of the floodplain. The type and number of threats posed by recreational facilities

Table 10-1. Physical and Land-Use Characteristics of Watersheds in the Santa Monica Mountains BPG region.

PHYSICAL CHARACTERISTICS						LAND USE			
WATERSHEDS (west to east)	**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]
Big Sycamore Canyon Creek	13,649	21	32	17.9	27	76%	< 1%	< 1%	99%
Arroyo Sequit	7,572	12	17	17.9	370	38%	3%	1%	96%
Malibu Creek	70,726	110	161	18.0	74,585	7%	23%	2%	75%
Las Flores Canyon Creek	2,908	5	6	18.5	1,144	5%	15%	< 1%	85%
Topanga Canyon Creek	12,616	20	30	17.9	5,561	2%	15%	< 1%	85%
TOTAL or AVERAGE	**107,471**	**168**	**246**	**18.0**	**81,687**	**---**	**18%**	**1%**	**81%**

[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 2000 block data (migrated), 2003
[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 Recreation Areas, State Parks, and County (from: http://old.casil.ucdavis.edu/casil/gis.ca.gov/teale/govtowna/)*

Figure 10-2. Photographs of Santa Monica Mountains BPG region.

Malibu Creek

Malibu Coast

Rindge Dam – Malibu Creek

Arroyo Sequit

Topanga Creek

varies significantly between watersheds, from single locations such a road crossing on Arroyo Sequit, to multiple sites, such as numerous floodplain campgrounds or multiple stream crossings in the Malibu Creek watershed.

The Malibu Creek watershed is highly constrained by two major dams: the Rindge Dam and the Malibu Lake Dam. The former structure is located approximately two stream miles upstream of the lagoon and blocks access to over 90% of the anadromous *O. mykiss* spawning and rearing habitat within Malibu Creek. Rindge Dam also has isolated native non-anadromous *O. mykiss* that would otherwise be anadromous and prevents the periodic re-colonization of upstream habitats that may experience periodic temporary extirpations as a result of natural stochastic processes, such as wildfires, droughts, and landslides. These dams have numerous effects on physical, hydrological, and habitat characteristics of the middle and lower reaches of the Malibu Creek. Dams also create and maintain favorable habitat conditions for several species of non-native fishes and bullfrogs, which may affect one or more life-history stages of *O. mykiss* either directly (*e.g.,* predation) or indirectly (*e.g.,* competition for food). Non-native crayfish, snails, fishes, and bullfrogs are particularly problematic in the Malibu Creek and Las Flores Canyon Creek watersheds.

The terrain of the Santa Monica Mountains results in development on steep slopes, often accompanied by road cuts to provide access, thus affecting watershed processes such as erosion and sedimentation. Development has also occurred along narrow riparian corridors, which encourages bank stabilization, levee construction, and other flood control activities, and physically constrains the ability of streams to maintain natural channel morphology and riparian vegetation.

Increased residential development, including high road densities, has significantly altered natural fire regimes in the Santa Monica Mountains BPG region because it has allowed human access to almost all portions of the component watersheds. Fires have consumed 71% to 100% of the Big Sycamore Canyon Creek, Arroyo Sequit, Malibu Creek, and Las Flores Canyon Creek watersheds within the past 25 years, including recent fires in 2007. Approximately 32% of the Topanga Canyon Creek watershed has burned in the last 25 years (see CAP Workbooks for specifics). Increased fire frequency can increase slope erosion and sediment inputs to streams, resulting in long-term changes to substrate composition and embeddedness, water quality (*e.g.*, turbidity), and water temperature (*e.g.*, loss of riparian canopy cover). Anadromous *O. mykiss* in each of the watersheds in the Santa Monica Mountains BPG region have been subjected to such secondary fire effects.

Estuarine habitat loss in the component watersheds of the Santa Monica Mountains BPG region ranges from 66 percent to 97 percent. Malibu Creek formerly had the largest estuary of any watershed in the BPG region and still has the highest amount of remaining estuarine habitat (34%). Topanga Canyon Creek has the second highest amount of remaining estuarine habitat (30%), but the estuary is highly impacted by Highway 1, commercial development, and recreational activities. Road construction, bridges, levees, floodplain encroachment by residential and commercial development (*e.g.*, the City of Malibu and Malibu Colony in Malibu Creek) have significantly reduced estuarine habitat in almost watersheds in this BPG region.

10.4 THREATS AND THREAT SOURCES

The relatively high population and development pressures along the coastal portions of the Santa Monica Mountains, coupled with the proximity to the densely populated Los Angeles Watershed, creates a series of recurring, severe to very severe threats to the persistence of anadromous *O. mykiss* in each of the component watersheds in this BPG region. The number of threat sources used by the CAP Workbooks in determining threat status for the Santa Monica Mountains BPG watersheds varied from eight in the Big Sycamore Canyon Creek watershed to 16 in the Malibu Creek watershed.

Ten anthropogenic activities ranked as the top five sources of stress to anadromous *O. mykiss* in the Santa Monica Mountains BPG (Table 10-2). Each watershed has a unique combination of threats; however, recurring threats among most or all of the watersheds include: high road density, including roads in close proximity to riparian corridors, impacts from recreational facilities, and barriers to migration at culverts and roadway stream crossings. Other threats are unique to particular watersheds, such as the Rindge and Malibu Lake dams on Malibu Creek.

10.5 SUMMARY

Road density is high throughout the Santa Monica Mountains BPG region, both on private and public lands. Road density, particularly roads that are within 300 feet of riparian corridors are affecting each of these watersheds by altering surface runoff patterns and stream hydrographs, and encroaching on floodplains and decreasing floodplain connectivity. Such road density creates the need for bank stabilization and levee construction to protect development, which in turn provides conduits for sediment, pollutant, and bacterial inputs to the watercourse. In other cases, road crossings create barriers to upstream and downstream movement of adult and juvenile anadromous *O. mykiss*. Table 10-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG.

Table 10-2. Threat source rankings in the component watersheds of the Santa Monica Mountains BPG region (see CAP Workbook for details).

Santa Monica Mountains BPG Component Watersheds (west to east)					
Threat Sources	Big Sycamore Canyon Creek	Arroyo Sequit	Malibu Creek	Las Flores Canyon Creek	Topanga Canyon Creek
Roads					
Recreational Facilities					
Other Passage Barriers					
Wildfires*					
Urban Development					
Levees and Channelization					
Dams and Surface Water Diversions					
Non-Native Species					
Pipeline Crossing*					
Non-Point Pollution					

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 recent fires in coastal watershed sin 2007 could result in significant impacts to steelhead habitats.*

Table 10-3. Critical recovery actions for Core 1 populations within the Santa Monica Mountains BPG.

POPULATION	CRITICAL RECOVERY ACTION
Malibu Creek	Remove Rindge and Malibu dams, and physically modify road crossings, to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.

Restoring conditions for anadromous *O. mykiss* passage, spawning, and/or rearing in these watersheds will require multiple, long-term, measures related to water management, recreation, and fish passage. Impediments to fish passage stemming from the construction and maintenance of roads and other transportation corridors, dams and other passage barriers, groundwater extraction, and modification of channel morphology and adjacent riparian habitats by flood control measures need to be further evaluated for this BPG. Additionally, the loss of estuarine functions caused by filling and pollution from point and non-point agricultural and other anthropogenic waste discharges need to be addressed further in this region

Threat sources should be the focus of a variety of recovery actions to address specific stresses on anadromous *O. mykiss* viability. Spatial and temporal data acquired on specific indicators associated with threat sources or stresses such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions part of any recovery strategy for the Santa Monica Mountains BPG. Tables 10-4 through 10-8 below rank and describe proposed recovery actions for each sub-watershed in the Santa Monica Mountains BPG including the estimated cost for implementing such actions over the first five fiscal years.

Table 10-4. Southern California Steelhead DPS Recovery Action Matrix for the Big Sycamore Canyon Creek Watershed (Santa Monica Mountains BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	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 deposition)		Wildfires	1, 4, 5	1A						
	Develop and implement a restoration and management plan for the Big Sycamore Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	2A						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2A						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	2B						
	Review development and management plans for Point Mugu State Park		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review Santa Monica Mountains National Recreation Area General Management Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Provide fish passage around dams or diversion or remove barriers		Dams and Surface Water Diversions	1, 3, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						

Table 10-5. Southern California Steelhead DPS Recovery Action Matrix for the Arroyo Sequit Creek Watershed (Santa Monica Mountains BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	1A						
	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 deposition)		Wildfires	1, 4, 5	1A						
	Physically modify dams/diversions to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement a plan to remove the small, non-functional water impoundments on the east and west forks of Arroyo Sequit		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	1B						
	Develop and implement a restoration and management plan for the Arroyo Sequit Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	2A						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2A						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	2B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	2B						
	Review development and management plans for Leo Carrillo State Park		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review Santa Monica Mountains National Recreation Area General Management Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	3B						

Table 10-6. Southern California Steelhead DPS Recovery Action Matrix for the Malibu Creek Watershed (Santa Monica Mountains BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Remove or physically modify Rindge and Malibu dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	1A						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	1B						
	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 deposition)		Wildfires	1, 4, 5	1A						
	Develop and implement a restoration and management plan for the Malibu Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	2A						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2A						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	2B						
	Review development and management plans for Malibu State Park		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review Santa Monica Mountains National Recreation Area General Management Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Las Virgenes Municipal Water District Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						

Table 10-7. Southern California Steelhead DPS Recovery Action Matrix for the Las Flores Canyon Creek Watershed (Santa Monica Mountains BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Physically dams/diversions to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	3A						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a restoration and management plan for the Los Flores Canyon Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Review development and management plans for Los Flores Creek and Estuary		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review Santa Monica Mountains National Recreation Area General Management Plan		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Las Virgenes Municipal Water District Wastewater Treatment Facility)		Urban Effluents	1, 4	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	3B						
	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 deposition)		Wildfires	1, 4, 5	3B						

Table 10-8. Southern California Steelhead DPS Recovery Action Matrix for the Topanga Canyon Creek Watershed (Santa Monica Mountains BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	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 deposition)		Wildfires	1, 4, 5	1A						
	Physically modify dams/diversions to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop and implement a restoration and management plan for the Topanga Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	2A						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a stream bank and riparian corridor restoration plan		Levees and Channelization	1, 4	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2B						
	Review development and management plans for Topanga State Park		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review Santa Monica Mountains National Recreation Area General Management Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	2B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	3B						

11. Mojave Rim 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 Mojave Rim BPG region encompasses three large coastal watersheds that drain the northern slopes of the Santa Monica Mountains and the coastal slopes of the San Gabriel and San Bernardino mountains in southern Los Angeles County, southwestern San Bernardino, and western Riverside and Orange counties: the Los Angeles River, San Gabriel River, and the Santa Ana River (Figure 4-10). Major tributaries in these drainages include: Arroyo Seco in the Los Angeles River watershed; the East and West forks of the San Gabriel River, and Mill and Lytle creeks in the upper Santa Ana River watershed. The upper portion of each of these watersheds includes steep, mountainous terrain and the lower watersheds cut across the Los Angeles Watershed—an extensive coastal plain. The Los Angeles, San Gabriel, and Santa Ana rivers have not always discharged to the Pacific Ocean at their current locations, but sometimes migrated across the Los Angeles Watershed and discharged as far west as Ballona Creek and as far east as present-day Huntington Beach. The Los Angeles, San Gabriel, and Santa Ana rivers currently discharge to the Pacific Ocean within 20 miles of each other in southern Los Angeles and northern Orange counties. The component watersheds are large, extending up to 83 miles inland in the case of the Santa Ana River watershed (Figure 11-1).

Average annual precipitation in these three watersheds is higher than that of the two adjacent BPG regions (*i.e.,* the Santa Monica Mountains and Santa Catalina Gulf Coast) because the upper watersheds include the San Gabriel and San Bernardino mountain ranges, whose upper elevations receive high annual rainfall and snowfall (Table 11-1). Rainfall along the coastal terrace portion of each of these watersheds is significantly lower than in the mountainous portions. Many of the mainstem rivers and tributaries in the Mojave Rim BPG region flow

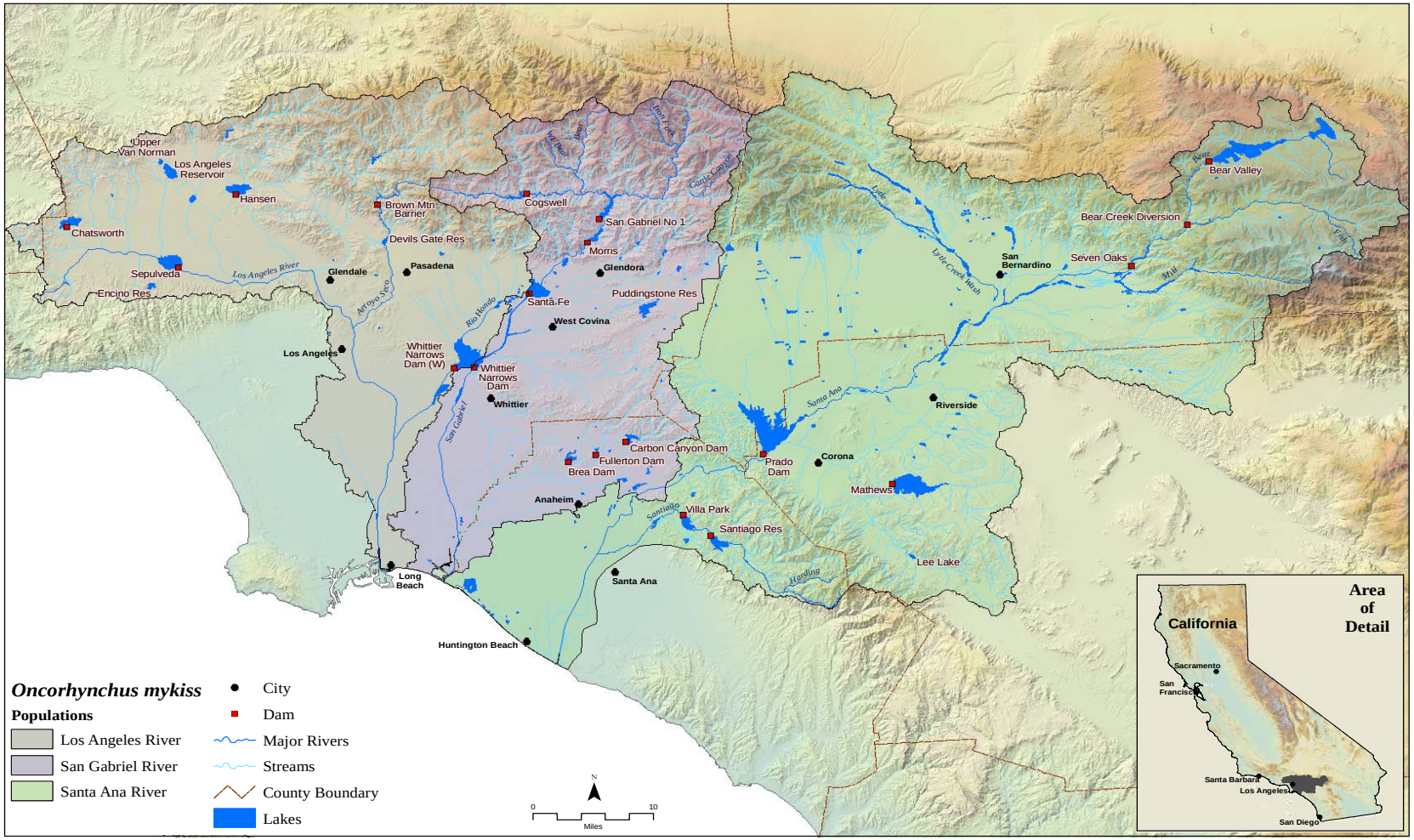

Figure 11-1. The Mojave Rim BPG region. Eight *O. mykiss* populations/watersheds were analyzed in this region: two in the Los Angeles River watershed; three in the San Gabriel River watershed, and; three in the Santa Ana River watershed.

across the relatively flat Los Angeles Watershed, with comparatively few small tributaries for watersheds of their size. As a result, the overall stream length in these watersheds is less than that in other BPG regions of comparable size.

11.2 LAND USE

Table 11-1 summarizes land use and population density in this region. This BPG region encompasses the second-largest metropolitan area in the United States. Human population density here is the highest of any of the five BPG regions, averaging 2,964 persons per square mile, over six times greater than the next most densely populated BPG region, the Santa Catalina Gulf Coast. Population density is much greater in some of the component watersheds, for example, the Los Angeles River watershed supports 5,237 persons per square mile. Population centers are mostly concentrated in the Los Angeles Watershed portions of these watersheds, but the interior portions of the Santa Ana River watershed also have extensive metropolitan areas.

There are at least 20 dams on the mainstem and/or major tributaries of each of the three drainages in this BPG that are large enough to be regulated by the California Department of Water Resources and/or Department of Defense (also see Figure 11-1 for distribution and size of reservoirs). These dams are owned and operated by federal, state, public utility, local government, or private interests for irrigation, flood control and storm water management, recreation, municipal water supply, fire protection, farm ponds, or some combination of these purposes. Most of the reservoirs and lakes in this region receive high recreational use and many are sources of non-native crayfish, fishes, and bullfrogs, and other non-native species that prey on or compete with *O. mykiss* for food and habitat space.

Public land ownership is concentrated in the upper portions of these watersheds, mostly within the Angeles National Forest, San Bernardino National Forest, and the northern portion of Cleveland National Forest. These three National Forests encompass several federally-designated wilderness areas: the San Gabriel and Sheep Mountain Wilderness Areas (Angeles National Forest); San Gorgonio, Cucamonga, San Jacinto, Santa Rosa, and Big Horn Mountain Wilderness Areas (San Bernardino National Forest), and Aqua Tibia Wilderness Area (Cleveland National Forest). Additionally, several rivers have been evaluated for inclusion in the federally-designated Wild and Scenic River system: Little Rock Creek, North and South forks of the San Gabriel River (tributaries to the San Gabriel River), Middle Fork Lytle Creek, Bear Creek, and Siberia Creek (tributaries to the Santa Ana River). Agriculture (row crop, orchard cultivation, and livestock ranching), used to be important land uses throughout the flatter portions of these watersheds, but have largely been displaced by urban development.

11.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for eight watersheds and sub-watersheds in the Mojave Rim BPG region. In general, instream, riparian, and floodplain conditions for anadromous *O. mykiss* are poor in this BPG region, reflecting pervasive urban conversion of watershed lands, particularly along the mainstems of these drainages, but even in the upper sub-watersheds of the

Table 11-1. Physical and Land Use Characteristics of Watersheds in the Mojave Rim BPG region.

PHYSICAL CHARACTERISTICS						**LAND USE**			
WATERSHEDS (north to south)	**Area** (acres)[1]	**Area** (sq. miles)[1]	**Stream Length**[2] (miles)	**Ave. Ann. Rainfall**[3] (inches)	**Total Human Population**	**Public Ownership***	**Urban Area**[5]	**Agriculture/ Barren**[5]	**Open Space**[5]
Los Angeles River	535,923	837	766	19.1	4,383,260	25%	61%	1%	38%
San Gabriel River	463,167	723	784	19.8	2,417,034	35%	53%	2%	46%
Santa Ana River	1,141,195	1,783	2,074	17.3	3,109937	29%	37%	8%	55%
TOTAL or AVERAGE	**2,140,285**	**3,343**	**3,624**	**18.7**	**9,910,231**	**30%**	**50%**	**4%**	**46%**

[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 2000 block data (migrated), 2003
[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.*

Santa Ana River watershed. The upper watersheds of the San Gabriel River watershed (East and West forks) still provide good to very good habitat conditions for resident *O. mykiss*, but these fish are isolated from the anadromous component of the population found in the mainstem. Several photographs of the Mojave Rim BPG region are provided in Figure 11-2.

The mainstems of the Los Angeles, San Gabriel, and Santa Ana rivers, including the main tributaries of the latter, provide little suitable spawning or rearing habitat for anadromous *O. mykiss* because of fish-passage barriers, channelization and flood control activities, loss of surface flows, and impaired water quality. The East and West forks of the San Gabriel River watershed, above Morris and Cogswell dams and their reservoirs, are mostly are in public ownership (Angeles National Forest and Cleveland National Forest) and these reaches provide relatively good habitat conditions. Both of these sub-watersheds support reproducing populations of non-anadromous *O. mykiss* that are isolated from their anadromous counterparts downstream of the dams.

Urban and agricultural conversion of coastal and middle reaches of these watersheds has created a number of severe stressors on anadromous *O. mykiss*. High road density throughout the floodplains has constricted the mainstems of these rivers to narrow channels, increased sediment and non-point pollutant inputs, and degraded rearing and spawning habitats (including estuaries). Nutrient and coliform bacteria loading from agricultural and wastewater treatment effluents degrades water quality in most of these drainages. In urban areas, channelization, levee construction, and other flood control activities have completely removed instream and riparian habitat from extensive reaches of the mainstems of the lower Los Angeles River, Santa Ana River, and San Gabriel.

Other significant threat sources in the Mojave Rim BPG region are recreational facilities, wildfire, and the loss of extensive estuarine habitat. Most watersheds receive very high recreational use because of their proximity to large urban areas. Trash, foot traffic, and off-road vehicle traffic have significantly affected instream and riparian habitats along extensive reaches of the upper watersheds. Fires have burned 21% and 26% of the San Gabriel River and Santa Ana River watersheds, respectively, in the past 25 years and may be significant, widespread, and long-term sources of sedimentation, turbidity, substrate embeddedness, and loss of riparian canopy cover. The historically extensive estuaries that formed at the mouths of the Los Angeles River, San Gabriel River, and Santa Ana River have been all but eliminated by urban and commercial development.

Despite widespread habitat degradation to the coastal and middle mainstems in these watersheds, native non-anadromous *O. mykiss* populations still persist upstream of the dams in this BPG region, and small numbers of anadromous *O. mykiss* attempt to enter and spawn in each of the watersheds when flow conditions are suitable.

11.4 THREATS AND THREAT SOURCES

Habitat impairments were rated as severe to very severe in five of the eight watersheds and sub-watersheds in this BPG region because of the very high human population densities. Ten anthropogenic activities ranked as the top five sources of stresses to steelhead and their habitat in

the Mojave Rim BPG (Table 11-2). These sources of threats focus on water management activities to serve municipal uses (dams, surface water diversions, and groundwater extraction). Dams and surface water diversions in this BPG region have been constructed to serve mostly urban purposes. These dams have numerous impacts on physical, hydrological, and habitat characteristics of the middle and lower reaches of mainstem rivers in this region. Dams also create and maintain favorable habitat conditions for several species of non-native fishes and bullfrogs that may affect one or more life-history stages of *O. mykiss* either directly (*e.g.,* predation) or indirectly (*e.g.,* competition for food). Non-native fishes, crayfish, and/or amphibians occur in the mainstems of the Los Angeles River, San Gabriel River, and Santa Ana River, as well as in most or all of the major tributaries. Water management practices and facilities have significantly altered natural sediment and hydrological processes in these watersheds. Widespread pumping of groundwater from aquifers throughout the region routinely eliminates surface flows in portions of most of these drainages. The magnitude of such losses of surface flows is greater during years of below-average precipitation. Another major indirect impact of dam construction and operation on the mainstem of the San Gabriel River is the periodic sluicing of sediments accumulated behind these dams, which severely degrades instream and riparian habitat quality for downstream of these structures.

Figure 11-2. Photographs of Mojave Rim BPG region.

East Fork San Gabriel River

Morris Dam – San Gabriel River

Santa Ana River Estuary

Table 11-2. Threat source rankings in the Mojave Rim BPG (see CAP Workbooks for individual watersheds for details).

Mojave Rim BPG Component Watersheds								
Threat Sources	Los Angeles River mainstem	Arroyo Seco	San Gabriel River mainstem	West Fork San Gabriel River	East Fork San Gabriel River	Santa Ana River mainstem	Lytle Creek	Mill Creek
Dams and Surface Water Diversions								
Flood Control								
Groundwater Extraction								
Levees and Channelization								
Urban Development								
Recreational Facilities								
Other Passage Barriers								
Agricultural Development								
Non-Point Pollution								
Wildfires*								

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

** Wildfires as a source of threats to steelhead habitat is not reflected in the top five threat sources in the CAP summary for these watersheds (see CAP workbooks), but is included here because of the extent and severity of recent (2005-2007) wildfires in this region.*

11.5 SUMMARY

Dams and water diversions (including groundwater extraction) along with flood control structures on the major rivers of the Mojave Rim BPG (Los Angeles River, San Gabriel River, and Santa Ana River) have had the most serve impacts on the anadromous *O. mykiss* populations in this BPG region by 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. Dams and surface water diversions in this BPG region have been constructed to serve mostly urban purposes. This BPG region encompasses the second-largest metropolitan area in the United States and human population density here is the highest of any of the five BPG regions. Such widespread urbanization has created a number of severe stressors for steelhead. Table 11-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG.

Table 11-3. Critical recovery actions for Core 1 populations within the Mojave Rim BPG.

POPULATION	CRITICAL RECOVERY ACTION
San Gabriel River	Implement operating criteria to ensure the pattern and magnitude of water releases from Morris, San Gabriel, and Cogswell dams comport with the natural or pre-dam pattern and magnitude of streamflow in downstream reaches. Physically modify Morris, San Gabriel, Cogswell, and Santa Fe dams, and road, highway, and railway crossings to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.

Restoring conditions for anadromous *O. mykiss* passage, spawning, and rearing in the Mojave Rim BPG region will require multiple, long-term, measures related to water management, recreation, and urban development. A fish passage barrier inventory and assessment should be conducted for each of the major watersheds. Impediments to fish passage stemming from the construction and operation of dams, groundwater extraction, and channel modification, and the loss of instream and adjacent riparian habitats by flood control measures need to be further evaluated for this BPG region. Additionally, the loss of estuarine functions caused by filling and pollution from point and non-point agricultural and urban waste discharges need to be addressed further in this region.

Threat sources discussed in this section should be the focus of a variety of recovery actions to address specific stresses on anadromous *O. mykiss* viability. Spatial and temporal data acquired on specific indicators associated with threat sources such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Mojave Rim BPG. Tables 11-4 through 11-6 below rank and describe proposed recovery actions for each sub-watershed in the Mojave Rim BPG including the estimated cost for implementing such actions over the first five fiscal years.

Table 11-4. Southern California Steelhead DPS Recovery Action Matrix for the Los Angeles River Watershed (Mojave Rim BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
Los Angeles River Mainstem											
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	2B						
	Physically modify or remove all fish passage barriers identified in the Los Angeles River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop an operational plan for releases from all dams (e.g., Whittier Narrows, Sepulveda, and Lower San Fernando dams)		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Review Los Angeles River Revitalization Master Plan and modify to provide for the protection and restoration of the Los Angeles River Watershed and riparian/floodplain areas		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	3B						
	Review U.S. Forest Service Angeles National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Develop and implement a riparian restoration plan that focuses on replacing artificial bank stabilization structures wherever feasible		Urban Development	1, 4	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Whittier Narrows Water Reclamation Facility, D.C. Tillman Water Reclamation Facility and Hyperion Wastewater Treatment Facility)		Urban Effluents	1, 4	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5							
Arroyo Seco River											
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	2B						
	Physically modify or remove all fish passage barriers identified in the Los Angeles River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4	3B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Review Arroyo Seco Master Plans (Hahanonga Watershed Park Master Plan, Central Arroyo Master Plan, Lower Arroyo Master Plan, Design Guidelines for the Arroyo Seco) and modify to provide for the protection and restoration of the Arroyo Seco River Watershed and riparian/floodplain areas		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Review U.S. Forest Service Angeles National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Develop and implement a riparian restoration plan that focuses on replacing artificial bank stabilization structures wherever feasible		Urban Development	1, 4	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5							

Table 11-5. Southern California Steelhead DPS Recovery Action Matrix for the San Gabriel River Watershed (Mojave Rim BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
San Gabriel River Mainstem											
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify or remove all fish passage barriers identified in the San Gabriel River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4	3B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement operating criteria to ensure the pattern and magnitude of water releases from Santa Fe, Morris, and San Gabriel dams comport with the natural or pre-dam pattern and magnitude of streamflow in downstream reaches		Dams and Surface Water Diversions	1, 3, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Physically modify Santa Fe, Morris, and San Gabriel dams to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a restoration and management plan for the San Gabriel estuary		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Review San Gabriel River Corridor Plan and modify to provide for the protection and restoration of the San Gabriel River Watershed and riparian/floodplain areas		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review U.S. Forest Service Angeles National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						
	Develop and implement a riparian restoration plan that focuses on replacing artificial bank stabilization structures wherever feasible		Urban Development	1, 4	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						
West Fork San Gabriel River											
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify or remove all fish passage barriers identified in the West Fork San Gabriel River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	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 deposition)		Wildfires	1, 4, 5	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4	3B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4	3B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement an operational plan for all dams (e.g., Cogswell Dam) in the West Fork of the San Gabriel River		Dams and Surface Water Diversions	1, 3, 4	3B						
	Provide fish passage around dams or diversions		Dams and Surface Water Diversions	1, 3, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	3B						
	Review U.S. Forest Service Angeles National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4							
East Fork San Gabriel River											
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify or remove all fish passage barriers identified in the East Fork San Gabriel River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4	3B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	3B						
	Review U.S. Forest San Bernardino National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Review California Regional Water Quality Control Board Los Angeles Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						

Table 11-6. Southern California Steelhead DPS Recovery Action Matrix for the Santa Ana River Watershed (Mojave Rim BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
Santa Ana River Mainstem											
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify or remove all fish passage barriers identified in the Santa Ana River Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4	3B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement an operational plan for all dams (e.g., Prado Dam) in the mainstem of the Santa Ana River		Dams and Surface Water Diversions	1, 3, 4	3B						
	Physically modify Prado Dam to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a restoration and management plan for the Santa Ana River estuary		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Review San Bernardino National Recreational Trail Master Plan and modify to provide for the protection and restoration of the Santa Ana River Watershed and riparian/floodplain areas		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	3B						
	Review U.S. Forest San Bernardino National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Retrofit storm drains in developed areas		Urban Development	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a riparian restoration plan that focuses on replacing artificial bank stabilization structures wherever feasible		Urban Development	1, 4	3B						
Lytle Creek											
	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 deposition)		Wildfires	1, 4, 5	1B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4	3B						
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	3B						
	Physically modify or remove all fish passage barriers identified in the Lytle Creek Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	3B						
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	3B						
	Review U.S. Forest San Bernardino National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Review California Regional Water Quality Control Board Santa Ana Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						
Mill Creek											
	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 deposition)		Wildfires	1, 4, 5	1B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4	3B						
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	3B						
	Physically modify or remove all fish passage barriers identified in the Mill Creek Watershed to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats		Culverts and Road Crossings (Passage Barriers)	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	3B						
	Develop and implement a plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a public educational program		Recreational Facilities	1,3,5	3B						
	Review U.S. Forest San Bernardino National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Review California Regional Water Quality Control Board Santa Ana Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						

12. Santa Catalina Gulf 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 the South-Central and Southern California, 2007

12.1 LOCATION AND PHYSICAL CHARACTERISTICS

The Santa Catalina Gulf Coast BPG region encompasses ten coastal watersheds of moderate size that drain the western slopes of the Santa Ana Mountains and Peninsular Range in southwestern Orange and Riverside counties southward through San Diego County to the United States-Mexico border (Figure 12-1). The upper portions of almost all of these watersheds include steep, mountainous regions and the lower watersheds cut across coastal terraces. Two watersheds, the Sweetwater River and Otay River, drain into San Diego Bay; the other eight watersheds drain directly into the Pacific Ocean. The component watersheds vary greatly in size (*e.g.*, the San Luis Rey River watershed is twelve times the size of the San Onofre Creek watershed).

Average annual precipitation in this region is relatively low and is spatially variable (Table 12-1). The coastal terrace portion of each of these watersheds receives significantly less rainfall that the interior montane portions. For example, the average annual total precipitation for the City of San Diego is about 9.9 inches; approximately half the average for the San Diego River watershed as a whole. Because of low rainfall, many of the drainages in this BPG are naturally seasonal or have extensive dry reaches during years of below-average precipitation. Stream length increases substantially in the interior portions of these watersheds because of the highly dissected terrain. Numerous tributaries contribute to the large total stream length for this region (4,235 miles).

12.2 LAND USE

Table 12-1 summarizes land use and human population density in this region. Population density varies widely between the component watersheds, but overall population density is the

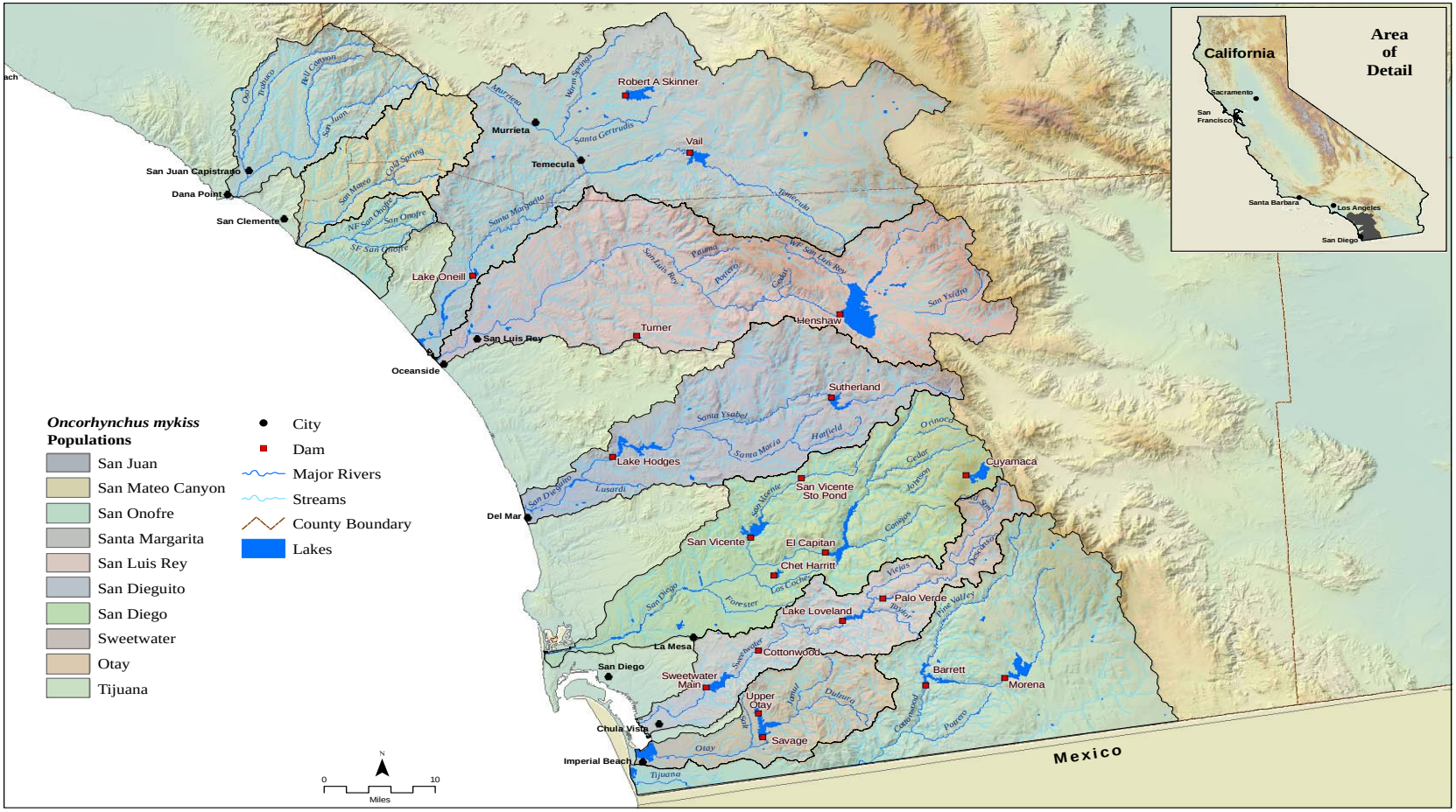

Figure 12-1. The Santa Catalina Gulf Coast BPG region. Ten steelhead populations/watersheds were analyzed in this region.

Table 12-1. Physical and Land Use Characteristics of Watersheds in the Santa Catalina Gulf Coast BPG region.

PHYSICAL CHARACTERISTICS						**LAND USE**			
WATERSHEDS (north to south)	**Area** (acres)[1]	**Area** (sq. miles)[1]	**Stream Length**[2] (miles)	**Ave. Ann. Rainfall**[3] (inches)	**Total Human Population**	**Public Ownership***	**Urban Area**[5]	**Agriculture/ Barren**[5]	**Open Space**[5]
San Juan River	113,977	178	280	12.5	191,997	37%	23%	7%	70%
San Mateo Creek	85,964	134	200	13.3	4,011	48%	3%	2%	95%
San Onofre Creek	37,617	59	86	14.0	4,981	---	6%	< 1%	94%
Santa Margarita River	472,633	738	949	15.6	181,376	10%	10%	13%	77%
San Luis Rey River	367,329	574	749	17.8	147,782	11%	8%	19%	73%
San Dieguito River	223,155	349	432	18.3	129,475	11%	18%	10%	72%
San Diego River	281,059	439	537	18.0	500,469	17%	26%	2%	72%
Sweetwater River	142,511	223	271	17.7	249,589	15%	27%	1%	72%
Otay River	93,504	146	256	16.7	122,342	---	16%	9%	75%
Tijuana River	301,649	471	475	17.3	75,117	38%	5%	2%	93%
TOTAL or AVERAGE	**2,119,398**	**3,311**	**4,235**	**16.1**	**1,607,140**	**---**	**14%**	**7%**	**79%**

[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 2000 block data (migrated), 2003
[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 only; does not include State or County Parks or Military Reservations (from: http://old.casil.ucdavis.edu/casil/gis.ca.gov/teale/govtowna/)*

second highest among the five BPG regions, averaging 485 persons per square mile. Population centers are concentrated on the coastal terrace portion of these watersheds, especially around San Diego Bay, which comprises one of the largest urban areas in the United States. Comparatively, the San Mateo Creek and portions of the Santa Margarita River and San Onofre Creek watersheds have very low population densities compared to the other watersheds (averaging less than 30 and 84 persons per square mile, respectively). Average population densities in the San Diego River and Sweetwater River watersheds, which encompass the greater San Diego urban area, average over 1,100 persons per square mile.

In most of these watersheds, the first land use changes involved row-crop agriculture (primarily orchard crops), and was followed by increasing urbanization, particularly on the coastal terraces. More recently, the upper watersheds of the Santa Margarita River and the San Luis Rey River have experienced rapid urban growth. Semi-developed rural land and orchards cover extensive portions of the coastal and middle portions of these watersheds. Public ownership of land (mostly in Cleveland National Forest lands) is largely concentrated in the interior, higher-elevation portions of these watersheds and includes several federally designated wilderness areas: the Agua Tibia, San Mateo, Pine Creek, and Hauser Wilderness Areas. Portions of several watersheds have also been evaluated for inclusion in the Federal system of Wild and Scenic Rivers: upper San Luis Rey River; Cottonwood Creek (tributary to the Tijuana River), upper San Mateo Creek, and Devil's Canyon (tributary to San Mateo Creek). The San Juan River/Trabuco Creek watershed contains large county parks (*e.g.*, Caspers Regional Park) that cover much of the upper watersheds of these drainages. The U.S. Marine Corps Base Camp Pendleton covers the coastal and middle portions of the San Mateo Creek, San Onofre Creek, and Santa Margarita River watersheds. However, public ownership constitutes a minority of overall land ownership in this BPG region, especially in the coastal and middle portions of these watersheds.

Agriculture (row crop and orchard cultivation and livestock ranching), are important land uses that directly or indirectly impact watershed processes throughout these watersheds. A major consequence of agricultural and urban growth in this region is reservoir development. There are at least 20 major dams in this region that are large enough to be regulated by the California Department of Water Resources and/or the Department of Defense (Figure 4-13). These dams are owned and operated by federal, state, public utility, local government, or private interests for irrigation, flood control and storm water management, recreation, municipal water supply, fire protection, farm ponds, or a combination of these purposes. Two of these dams create enlarged natural lakes: Lake Henshaw in the San Luis Rey River watershed and Vail Lake in the Santa Margarita River watershed. None of these facilities have incorporated fish passage provisions, including downstream flow provisions, into their operation. Most of the reservoirs and lakes in this region receive high recreational use and many are sources of non-native crayfish, fishes, and bullfrogs, and other non-native species that prey on or compete with *O. mykiss* for food and habitat.

12.3 CURRENT WATERSHED CONDITIONS

Watershed conditions were assessed for the 10 watersheds and sub-watersheds in the Santa Catalina Gulf Coast BPG region. In general, instream, riparian, and floodplain conditions for anadromous *O. mykiss* in this BPG region are rated as "Poor" to "Very Poor", reflecting pervasive

agricultural and urban land uses, particularly along the middle and coastal reaches. In contrast, the upper watersheds of many of these drainages are in relatively good condition (exceptions are the upper watersheds of the Santa Margarita River and San Luis Rey River). Relatively few indicators were rated as "Good" or "Very Good." Several photographs of the Santa Catalina Gulf Coast BPG region are provided in Figure 8.2.

Urban and agricultural conversion of coastal and middle reaches of these watersheds has created a number of severe stressors for anadromous *O. mykiss* in this BPG region. High road density increases sediment and pollutant inputs to these streams and their estuaries, degrading rearing and spawning habitat and increasing mortality of one or more life stages. In many urban and agricultural areas, channelization, levee construction, and other flood control activities have completely removed instream and riparian habitat or reduced instream refugia and structural complexity to a minimum. Flood control structures are widespread along the lower portions of drainages that pass through large urban areas, such as San Juan Creek, San Luis Rey River, San Dieguito River, San Diego River, Sweetwater River, and the Otay River.

At least 20 major dams and surface water diversions without provisions for fish passage have been constructed to serve agricultural, urban, and recreational purposes. These structures and water management practices have significantly altered natural sediment and hydrological processes in these watersheds. Dams also create and maintain favorable habitat conditions for several species of non-native fishes and bullfrogs that may affect one or more life-history stages of *O. mykiss* either directly (*e.g.,* predation) or indirectly (*e.g.,* competition for food). Non-native crayfish, fishes, and bullfrogs occur in all of the drainages in this BPG region, but are particularly abundant in the San Mateo Creek, San Onofre Creek, and Santa Margarita River watersheds. Widespread pumping of groundwater routinely eliminates surface flows in portions of most of these drainages, particularly during years of below-average precipitation.

Severe loss of estuary habitat has occurred throughout the Santa Catalina Gulf Coast BPG region. Only the San Mateo Creek estuary was rated as "Good" (based on remaining acreage), with 76% of the historic estuary intact. Between 48% and 95% of estuary areas in the other watersheds in the BPG region have been lost. Development of recreational facilities within the floodplain and/or mouths of the San Mateo Creek, San Onofre Creek, Santa Margarita River, and Tijuana River watersheds are sources of estuarine, riparian, and instream habitat degradation and loss. Loss of estuarine habitat as a result of recreational development is most pronounced around the mouths of the San Juan Creek, San Dieguito Creek, San Diego River, Sweetwater River, and Otay River. Significant portions of the Santa Margarita River estuarine complex have been isolated from regular freshwater inflow as a result of the construction of the Interstate Highway 5. Off-road vehicle activity is common in the middle and upper portions of several of these watersheds (*e.g.*, upper Santa Margarita and San Luis Rey watersheds). The remaining estuarine habitats are subject to constriction and isolation from urban, agricultural, and/or recreational development, as well as degradation of water quality from surface runoff from roads, wastewater treatment effluents, and losses of upstream surface flows.

Fires have burned between 22% (San Mateo Creek) and 74% (San Diego River) of the watersheds in this BPG region in the past 25 years (including significant coastal portions of watersheds in southern Orange and northern and central San Diego counties in 2007). Increased fire frequency

can increase erosion and sediment input to streams, resulting in long-term changes to substrate composition and embeddedness, water quality (*e.g.*, turbidity), and water temperature (loss of riparian canopy cover). Anadromous *O. mykiss* in each of the watersheds in the BPG region have been subjected to these secondary effects of fire.

Despite widespread and varied habitat degradation to the coastal and middle portions, native non-anadromous *O. mykiss* populations still inhabit the relatively high-quality habitat that remains upstream of most of the dams in this region (*e.g.*, Pine Valley Creek in the Tijuana River watershed), and small numbers of anadromous *O. mykiss* attempt to enter and spawn in each of the watersheds of the Santa Catalina Gulf Coast BPG when flow conditions are suitable.

12.4 THREATS AND THREAT SOURCES

Varying numbers and intensity of habitat impairment (threats) were identified in the CAP Workbooks analyses, ranging from 11 in the San Onofre Creek watershed to 17 in the Santa Margarita River and San Luis Rey River watersheds. NMFS notes that portions of the San Luis Rey River run through tribal lands and additional information is needed to assess the conditions of those portions of the river. Most of the habitat impairments across the BPG were rated as "Severe" to "Very Severe" in all but the San Mateo Creek and San Onofre Creek watersheds, and are related to high human population densities and urban and agricultural conversion of watershed lands. The relatively good habitat quality in San Mateo and San Onofre creeks, and, to a lesser degree in the Santa Margarita River, is due to the presence of the Camp Pendleton Marine Corps Base, which covers substantial portions of the coastal and middle reaches of these watersheds. The upper watersheds, above dams and reservoirs, mostly are in public ownership within Cleveland National Forest. These reaches provide relatively good habitat conditions for anadromous *O. mykiss* and support reproducing populations of non-anadromous *O. mykiss*.

Twelve anthropogenic activities ranked as the top five sources of stress to steelhead in the Santa Catalina Gulf Coast BPG (Table 12-2). The most significant feature of this ranking is that each of the top five threats are rated as "Severe" or "Very Severe" and that groundwater extraction, dams and/or surface water diversions are pervasive threat sources in each of the watersheds. Although open space is the dominant land use in this BPG region, urban and agricultural conversion of the coastal and middle portions of these watersheds, especially within the floodplains of these drainages, has disproportionately degraded habitat conditions for anadromous *O. mykiss*.

Water management activities associated with urban and agricultural conversion of watershed lands are the most pervasive threat sources in this BPG region. Climatically, the Santa Catalina Gulf Coast BPG region is classified as semi-arid, and anadromous *O. mykiss* must compete for water with urban and agricultural interests throughout these watersheds. Widespread pumping of groundwater routinely eliminates surface flows in portions of most of these drainages. The magnitude of such losses of surface flows is greater during years of below-average precipitation. High road density and associated stream crossings (culverts, bridges, *etc.*) in most of the urbanized portions of these watersheds are also a common source of passage impediments for anadromous *O. mykiss*. As a result of the widespread construction of dams in the lower and middle reaches of these watersheds, non-anadromous *O. mykiss* populations are now isolated in

the upper watersheds where higher-quality instream and riparian habitat still exists above reservoirs.

Figure 12-2. Photographs of Santa Catalina Gulf Coast BPG region.

Arroyo Trabuco Creek

San Luis Rey River

San Mateo Creek

Cottonwood Creek

***O. mykiss* – Cottonwood Creek**

Table 12-2. Threat source rankings in watersheds of the Santa Catalina Gulf Coast BPG (see CAP Workbooks for details).

Santa Catalina Gulf Coast Component Watersheds (north to south)										
Threat Sources	San Juan Creek	San Mateo Creek	San Onofre Creek	Santa Margarita River	San Luis Rey River	San Dieguito River	San Diego River	Sweetwater River	Otay River	Tijuana River
Groundwater Extraction										
Dams and Surface Water Diversions										
Urban Development										
Agricultural Development										
Levees and Channelization										
Other Passage Barriers										
Recreational Facilities										
Non-Native Species										
Roads										
Flood Control										
Non-Point Pollution										
Agricultural Effluents										
Wildfires*										

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

** Wildfires were not recognized during the CAP Workbook analyses as one of the top five threats in these watersheds, but recent fires in coastal watersheds of southern Orange and northern and central San Diego counties in Fall, 2007 could result in significant, long-term impacts to steelhead habitat.*

12.5 SUMMARY

Dams and water diversions (including groundwater extraction) along with flood control structures on the major rivers of the Catalina Gulf Coast BPG region (Santa Margarita River, San Luis Rey River, San Dieguito River, San Diego River, Sweetwater River, Otay River and Tijuana River) have had the most serve impacts on the anadromous *O. mykiss* populations in this BPG by 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. Table 12-3 summarizes the critical recovery actions needed within the Core 1 populations of this BPG.

Table 12-3. Critical recovery actions for Core 1 populations within the Santa Catalina Gulf Coast BPG.

POPULATION	CRITICAL RECOVERY ACTION
San Juan Creek	Physically modify road crossings, highways, and railways to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.
San Luis Rey River	Implement operating criteria to ensure the pattern and magnitude of water releases from Pilgram, Turner, Lower and Upper Stehly, Aqua Tibia, Henshaw, and Eagles Nest dams comport with the natural or pre-dam pattern and magnitude of streamflow in downstream reaches. Physically modify all dams, and road, highway, and railway crossings to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitats. Identify, protect, and where necessary, restore estuarine and freshwater rearing habitats.

Restoring conditions for anadromous *O. mykiss* passage, spawning, and rearing in the Santa Catalina Gulf Coast BPG region will require multiple, long-term, measures related to water management, recreation, and urban development. A fish-passage barrier inventory and assessment should be conducted for each of the major watersheds. Impediments to fish passage stemming from the construction and operation of dams, groundwater extraction, and channel modification, and the loss of instream and adjacent riparian habitats by flood control measures need to be further evaluated for this BPG region. Additionally, the loss of estuarine functions caused by filling and pollution from point and non-point agricultural and urban waste discharges need to be addressed further in this region.

Threat sources discussed in this section should be the focus of a variety of recovery actions to address specific stresses on anadromous *O. mykiss* viability. Spatial and temporal data acquired on specific indicators associated with threat sources such as water temperature, pH, nutrients, *etc.*, are generally inadequate to be the target of specific recovery actions. This type of data acquisition should be the subject of site-specific investigations in order to refine the primary recovery actions or to target additional recovery actions as part of any recovery strategy for the Santa Catalina Gulf Coast BPG. Tables 12-4 through 12-8 below rank and describe proposed recovery actions for each sub-watershed in the Santa Catalina Gulf Coast BPG including the estimated cost for implementing such actions over the first five fiscal years.

Table 12-4. Southern California Steelhead DPS Recovery Action Matrix for the San Juan River/Trabuco Creek Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	1B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	1B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	1B						
	Develop and implement a restoration and management plan for the San Juan Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	1B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify San Juan Creek Trail Plan, Trabuco Creek Nature Trail Plan, and Descanso Park Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to re-configure or relocate the existing Doheny State Beach parking lot to provide a minimum 100-foot wide buffer around the estuary; restore and vegetate buffer area with native, locally occurring species.		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Cleveland National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	2B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	3B						

Table 12-5. Southern California Steelhead DPS Recovery Action Matrix for the San Mateo Creek Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	1A						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	1A						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	1A						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	1B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	1B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	1B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	1B						
	Develop and implement a restoration and management plan for the San Mateo Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	1B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	1B						
	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 deposition)		Wildfires	1, 4, 5	1B						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	2B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						
	Review and modify San Onofre State Park Plan and San Diego Regional Trails Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to modify the existing day-use parking lot to provide a minimum 100-foot wide buffer around the estuary; restore and vegetate buffer area with native, locally occurring species.		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Marine Corps Camp Pendleton Integrated Natural Resources Management Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	2B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	2B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., U.S. Marine Corps Camp Pendleton Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5							

Table 12-6. Southern California Steelhead DPS Recovery Action Matrix for the San Onofre Creek Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a restoration and management plan for the San Onofre Creek Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	1B						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2A						
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	2B						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify San Onofre State Park Plan and San Diego Regional Trails Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to modify the existing day-use parking lot to provide a minimum 100-foot wide buffer around the estuary; restore and vegetate buffer area with native, locally occurring species.		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Marine Corps Camp Pendleton Integrated Natural Resources Management Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						

Table 12-7. Southern California Steelhead DPS Recovery Action Matrix for the Santa Margarita River Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Santa Margarita River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	1B						
	Develop an operational plan for releases from all dams (e.g., Lake O'Neill Dam, Vail Dam, Robert A. Skinner Dam)		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify Santa Margarita River Watershed Management Plan and San Diego Regional Trails Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Cleveland National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Fallbrook Public Utility District Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	3B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						

Table 12-8. Southern California Steelhead DPS Recovery Action Matrix for the San Luis Rey River Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4	1B						
	Develop and implement a restoration and management plan for the San Luis Rey River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Develop and implement operating criteria to ensure the pattern and magnitude of water releases from Pilgram, Turner, Lower and Upper Stehly, Aqua Tibia, Henshaw, and Eagles Nest dams comport with the natural or pre-dam pattern and magnitude of streamflow in downstream reaches		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	2B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify San Luis Rey River Park Master Plan and San Diego Regional Trails Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Cleveland National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Buena Sanitary District Wastewater Treatment Facility and Oceanside Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						

Table 12-9. Southern California Steelhead DPS Recovery Action Matrix for the San Dieguito River Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the San Dieguito River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	1B						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop an operational plan for releases Fairbanks, Upper and Lower 4 S, 4 S Ranch, Lake Hodges, and Sutherland dams		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	2B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	2B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Review and modify aggregate mining operations		Mining and Quarrying	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify San Dieguito River Park Concept Plan and San Diego Regional Trails Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Cleveland National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						

Table 12-10. Southern California Steelhead DPS Recovery Action Matrix for the San Diego River Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the San Diego River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., Padre Dam Water Reclamation Facility)		Urban Effluents	1, 4	1B						
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	1B						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop an operational plan for releases Murray, San Vicente, El Capitan, and Cuyamaca dams		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Cleveland National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	3B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Review and modify San Diego River Park Master Plan, San Diego Regional Trails Plan, and San Diego River Watershed Management Plan		Recreational Facilities	1, 2, 3, 4, 5							

Table 12-11. Southern California Steelhead DPS Recovery Action Matrix for the Sweetwater River Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Sweetwater River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	1B						
	Develop an operational plan for releases from Sweetwater Main, Willow Tree, Loveland, and Palo Verde dams		Dams and Surface Water Diversions	1, 3, 4	2A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	2B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	2B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	2B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	2B						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify Sweetwater River Watershed Management Plan and Sweetwater Marsh National Wildlife Management Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Cleveland National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	2B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., San Diego City Point Loma Wastewater Treatment Facility)		Urban Effluents	1, 4	2B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	2B						
	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		Wildfires	1, 4, 5	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	preserve natural ecosystem processes (including sediment deposition)										
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						

Table 12-12. Southern California Steelhead DPS Recovery Action Matrix for the Otay River Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	2B						
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	3A						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4	3B						
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,	3B						
	Relocate livestock grazing and water sources		Agricultural Development	1, 4,	3B						
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,	3B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	3B						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop an operational plan for releases from Salvage and Upper Otay dams		Dams and Surface Water Diversions	1, 3, 4	3B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	3B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop and implement a restoration and management plan for the Otay River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	3B						
	Review and modify Otay River Watershed Management Plan and Otay Valley Regional Park Management Plan		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Review U.S. Forest Service Cleveland National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	3B						
	Relocate roadways outside of riparian corridor and restore abandoned roadways		Roads	1, 4	3B						
	Develop and implement a plan to remove or reduce approach-fill for Interstate 5 bridge		Roads	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Retrofit storm drains to filter runoff from roadways		Roads	1, 4	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits		Urban Effluents	1, 4	3B						
	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 deposition)		Wildfires	1, 4, 5	3B						

Table 12-13. Southern California Steelhead DPS Recovery Action Matrix for the Tijuana River Watershed (Santa Catalina Gulf Coast BPG).

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Conduct a watershed-wide fish passage barrier assessment		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Physically modify road crossings, highways, and other passage barriers to allow unimpeded volitional migration of steelhead to upstream spawning and rearing habitat		Culverts and Road Crossings (Passage Barriers)	1, 4	1A						
	Develop and implement a restoration and management plan for the Tijuana River Estuary		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review and modify applicable County and/or City Local Coastal Plans		Other Recovery Actions	1, 2, 3, 4, 5	1B						
	Review, assess and modify if necessary all NPDES wastewater discharge permits (e.g., South Bay International Wastewater Treatment Facility and South Bay Water Reclamation Facility)		Urban Effluents	1, 4	1B						
	Review California Regional Water Quality Control Board San Diego Region Watershed Plans and modify applicable stormwater permits		Urban Effluents	1, 4	1B						
	Develop and implement water management plan		Dams and Surface Water Diversions	1, 3, 4	2B						
	Develop an operational plan for releases from all dams (e.g., Barrett Dam, Henry Jr. Dam, Campo Lake Dam, Morena Dam, Corte Madera Dam, Thin Valley Dam)		Dams and Surface Water Diversions	1, 3, 4	2B						
	Conduct hydrological analysis (groundwater)		Groundwater Extraction	1, 4	2B						
	Develop and implement a groundwater monitoring program		Groundwater Extraction	1, 4	2B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a non-native species monitoring program		Non-Native Species	1, 3, 5	2B						
	Develop and implement a public educational program on non-native species impacts		Non-Native Species	1, 3, 5	2B						
	Review and modify Tijuana River Watershed Management Plan, Tijuana River Valley Regional Park Management Plan, Border Field State Park Management Plan, and Tijuana River National Estuarine Research Reserve Plan		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Review U.S. Forest Service Cleveland National Forest Land Management Plan (Southern California National Forest Vision, Forest Strategy, and Design Criteria)		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Develop and implement a public educational program on watershed processes		Recreational Facilities	1, 2, 3, 4, 5	2B						
	Retrofit storm drains in developed areas		Urban Effluents	1, 4	2B						
	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 deposition)		Wildfires	1, 4, 5	2B						
	Develop and implement a plan to minimize runoff from agricultural activities		Agricultural Effluents	1, 4	3B						
	Develop and implement a plan to minimize disturbance of instream habitats and riparian vegetation		Flood Control	1, 4	3B						
	Develop and implement a flood control maintenance program		Levees and Channelization	1, 4	3B						
	Develop and implement a plan to restore natural channel features where feasible		Levees and Channelization	1, 4	3B						

Action #	Recovery Action Description	Responsible Parties	Threat Source	Listing Factors (1 - 5)	Action Rank (1A, 1B, 2A, 2B, 3A, 3B)	Task Duration	Fiscal Year Costs ($K)				
							FY1	FY2	FY3	FY4	FY5
	Develop and implement a plan to vegetate levees and minimize herbicide use near levees		Levees and Channelization	1, 4	3B						
	Develop and implement a watershed-wide plan to assess the impacts of non-native species and develop control measures		Non-Native Species	1, 3, 5	3B						
	Develop, adopt, and implement urban land-use planning policies and standards		Urban Development	1, 4	3B						
	Develop and implement a watershed-wide sediment management plan		Agricultural Development	1, 4							
	Develop, adopt, and implement agricultural land-use planning policies and standards		Agricultural Development	1, 4,							
	Relocate agricultural development and restore riparian zone		Agricultural Development	1, 4,							

13. Southern California 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 southern California steelhead will require a better understanding of the biology of the species, a method of monitoring the status of individual populations and the DPS, and a plan for tracking the effectiveness of the recovery actions and adjusting the recovery actions, as well as the over-all recovery strategy.

13.1.1 Southern California Steelhead Research

In 2002 the National Marine Fisheries Service (NMFS) convened a team of scientific specialists, know as the Technical Recovery Team (TRT), whose mission was to survey existing scientific information on steelhead ecology, and formulate a biological framework for a recovery plan for Southern California steelhead (Boughton and Fish 2003; Boughton *et al.*, 2005; Boughton and Goslin 2006; Boughton *et al.*, 2006, 2007).

The current state of knowledge of steelhead ecology is largely descriptive and qualitative. This has led to important uncertainties in the viability framework, which involved quantitative goals for distribution and abundance of steelhead trout and general strategies for how to achieve these goals. In general, the TRT approached uncertainty about recovery goals with a risk-averse, or precautionary, stance, consistent with accepted practice in conservation biology (McElhany *et al.*, 2000).

The TRT recognized early on that some key uncertainties involved in recovery planning arose from the qualitative nature of the current understanding, and could be improved by a carefully conceived and planned program of scientific research and monitoring. The benefits of pursuing such a program would be a more effective, and more-cost efficient, recovery effort for steelhead.

The over-riding need is for the scientific framework to become *quantitative* about certain aspects of southern California steelhead populations—especially their annual run size, along with year-to-year variability over the long term; and the quantitative response of steelhead runs to specific recovery actions. These are related to the two over-arcing questions of steelhead recovery in this region: how do we improve the distribution, abundance, and resilience of steelhead trout populations, and how much do we need to improve it 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 address two levels of organization, population and the Evolutionarily Significant Unit (ESU) which includes all life-history forms. The *O. mykiss* ESUs in this recovery planning area are composed of both anadromous and nonanadromous fish, but only the latter is on the endangered species list, under the "Distinct Population Segment" provision of the Federal Endangered Species Act. One of the principal uncertainties hindering and confusing the recovery effort is the relationship between the anadromous and non-anadromous (or "freshwater-resident") forms of the species. Following convention, the term "steelhead trout" is used for the anadromous fish, "rainbow trout" for non-anadromous fish, and "*O. mykiss*" when referring to both or either. The goal of the recovery plan is to ensure the continued persistence of steelhead trout in the region over the long term (Boughton *et al.,* 2007), but it is likely that rainbow trout have some role in securing this future, and thus the viability criteria have provisions for both forms of the species.

13.2.1 Population-Level Criteria

The TRT considered *O. mykiss* in the region to be grouped into demographically independent populations. Generally, each discrete coastal watershed in the region was assumed to have historically supported one demographically independent population of *O. mykiss. I*f migratory steelhead frequently move from one watershed to another, the one-watershed-one-population assumption may have some important exceptions, with implications for recovery planning, and this is one of the key uncertainties about population structure discussed in the next section.

The TRT proposed population-level viability criteria for determining whether a demographically independent population of *O. mykiss* should be considered viable for the purpose of steelhead recovery. The TRT identified two choices for meeting the viability criteria. The first was to meet a set of criteria: a population must exhibit a mean annual run size of at least 4,150 steelhead trout, including during periods of poor ocean conditions (such as occurred from the late 1970s through early 1990s). Additionally, the spawner densities in the river systems needed to meet a minimum density threshold (fish per km. of stream channel), a quantitative criterion yet to be determined.

The second choice was to meet a performance-based criterion, demonstrating that the extinction risk for steelhead trout is less than 5% over 100 years, using commonly accepted quantitative methods from conservation biology, demographic data from the population in question, and passing an independent scientific review.

The performance-based criteria cannot be applied in a meaningful way until an effort to monitor steelhead run sizes has been in place for a decade or more. The reason is that extinction risk is very sensitive to not just run size, but also its year-to-year variability and it will be necessary to monitor steelhead runs for at least a decade, more likely two, before this key quantity can be estimated with reasonable accuracy and precision. In the meantime, the prescriptive criteria ensures that year-to-year variability in run size, whatever its probable magnitude, is unlikely to pose a significant extinction risk.

If year-to-year variability turns out to be relatively modest, a mean run size smaller than 4,150 steelhead would perhaps be sufficient to ensure a low extinction risk. This was one of the reasons for including the option for performance-based viability criteria, as a mechanism for refining the viability criteria as more is learned over time.

Extinction risk for individual steelhead runs may also be sensitive to the influence of rainbow trout, if the trout tend to stabilize or augment those runs through the mechanism of rainbow trout regularly having anadromous steelhead amongst their 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 only a fraction of the 4,150 spawners would need to exhibit the anadromous life history.

In the absence of specific information about the role of life-history crossovers, the TRT took a precautionary approach (i.e., it was assumed there was not any beneficial effect of crossovers). This meant that the 4,150 spawners per year required for viability must be composed entirely of steelhead trout, rather than a mixture of rainbow and steelhead to ensure viability. However, the TRT also believed that the criteria should cover the possibility that the beneficial effect not only exists, but is necessary for viability. This led to additional criteria that the anadromous and freshwater resident life-history types should both be expressed in populations for them to be considered viable.

It would be useful to learn whether rainbow trout significantly enhance or stabilize steelhead runs. If rainbow trout turn out to 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, or it could incorporated into a performance-based assessment of risk that might have different requirements for run size and anadromous fraction. Research into these topics could potentially provide flexibility in the recovery process while maintaining acceptably low extinction risk.

13.2.2 ESU/DPS-Level Criteria

The TRT outlined a set of ESU/DPS-level criteria, which if met would indicate that a steelhead Distinct Population Segment has been successfully recovered. Satisfying the ESU/DPS-level criteria requires a set of *O. mykiss* populations in which:

- Each population satisfies the population-level criteria described above, and
- The set of populations as a whole satisfies requirements for ecological representation and redundancy, and
- The set of populations as a whole exhibit all three life-history types (fluvial-anadromous, lagoon-anadromous, freshwater resident)

The criteria for representation and redundancy have two purposes. First, to protect the genetic and ecological diversity that ensures the long-term viability of the species under changing conditions, the set of populations should *represent* the entire range of ecological and genetic conditions originally present in the ESU/DPS. Second, to protect against catastrophic loss of entire populations due to disease, forest fires, drought, *etc.*, the set of populations should exhibit *redundancy* with respect to the range of ecological and genetic conditions originally present in the ESU. This ensures that if entire populations are lost from a particular ecotype, for example, there will be at least one other population in that ecotype that survives, and can serve as a reservoir of individuals retaining the genetic and phenotypic adaptations necessary for inhabiting that ecotype. Ultimately such individuals would be necessary for recolonizing the watersheds of the populations that were lost.

The TRT developed criteria for representation and redundancy by grouping the region's populations of *O. mykiss* into biogeographic groups, and specifying a minimum level of redundancy (number of viable populations) within each group. In addition, the TRT recommended that the core populations should inhabit watersheds with drought refugia, should be separated from one another by at least 68km if possible, and should exhibit three life-history types—the rainbow trout form described previously, and two forms of steelhead trout, the lagoon-anadromous form and the fluvial-anadromous form, that is described more fully below.

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.*, 2007). Summer air temperatures, which strongly influence whether summer stream temperatures are cool enough for the fish, were a key consideration. The most important split was between coastal groups of populations, in which cool mesoclimates are maintained by proximity to the ocean, and interior groups of populations, where cool mesoclimates are primarily confined to mountain ranges, and are maintained by the temperature lapse rate (i.e. the reduction in temperature with increased elevation).

The criteria for redundancy within each biogeographic group were based on an assessment of catastrophic risks posed by wildfires and debris flows. However, the assessment was based on historical pattern and did not include considerations of climate change, which is likely going to have a large impact on the region (see discussion below).

The TRT also considered the catastrophic risk posed by drought, but could not incorporate it into the criteria due to insufficient information. The broad spatial extent of the typical drought in the region indicated that simple redundancy was not a suitable strategy for protecting the species from its effects. What is needed is information for identifying watersheds having potential as drought refugia—stream systems that maintain suitable summer baseflows and water temperatures during severe multi-year droughts.

The broad-scale climatic factors that control the distribution of *O. mykiss* in the region appear to be summer air temperatures, annual precipitation, and the severity of winter storms, the latter having its effect by determining the power of high flow events that organize the distribution and extent of in-stream steelhead habitat. All of these factors are likely to undergo a permanent shift as part of CO_2-induced climate change. In addition, the region's frequent wildfires strongly influence the sediment budgets of streams, and thus the distribution of steelhead habitat. The overall wildfire regime is also likely to undergo a permanent shift in response to climate change. The magnitudes of these shifts and the magnitude of their direct and interaction effects on stream habitat is not yet clear. Thus a key uncertainty is how to plan for climate change at the level of the ESU, and also at the level of individual stream watersheds.

13.3 RESEARCH FOCUS: ANADROMY, POPULATION STRUCTURE, AND CLIMATE CHANGE

The natural dynamics of watersheds and stream systems maintain steelhead habitat in the recovery planning area in a stochastic, dynamic equilibrium, though this equilibrium can involve dramatic processes such as floods and forest fires that disrupt habitat in the short term (but ensure its continued existence over the long term). Other processes that circumscribe the productivity of freshwater steelhead habitat, such as the severity of the dry season or the pattern of high-flow events during the wet season may affect reproductive success. These ecological constraints are generally understood at a qualitative level, but this level of knowledge is in some cases too vague to provide specific guidance for setting goals and choosing specific recovery actions. The research program supporting steelhead recovery in this region should focus on quantitative studies that 1) identify ecological factors that promote anadromy; 2) clarify key aspects of population structure; and 3) support planning for climate change.

13.3.1 Ecological Factors that Promote Anadromy

The focus of recovery is to recover and secure the anadromous form of *O. mykiss*, and that involves restoring ecological conditions that specifically promote the abundance of the anadromous form. While it is necessary to have migration corridors for steelhead to reach a spawning 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.

The most settled question is the definite fecundity advantage of sea-going females. As shown in Figure 13-1, an adult female's egg production scales exponentially to its body length, and adult *O. mykiss* are generally able to attain much larger sizes in the ocean than in freshwater.

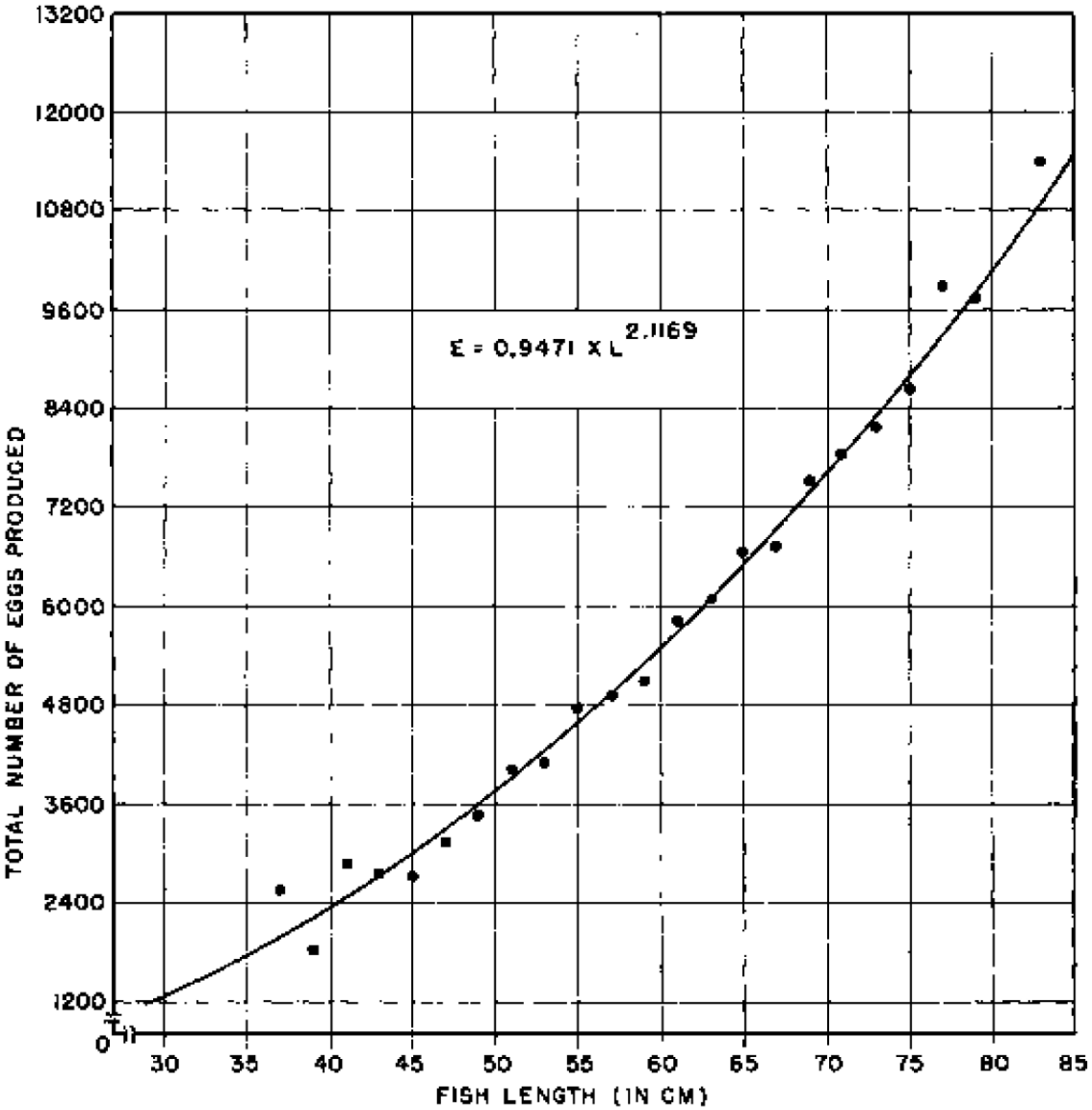

Figure 13-1. Fecundity as a function of body size for female steelhead sampled from Scott Creek in Santa Cruz County. Reproduced from Shapovalov and Taft (1954).

Thus, a typical female rainbow trout might attain a length of 35 cm, enabling her to produce 1800 eggs annually, whereas a medium sized steelhead female at 60 cm could produce over 3.5 times that number. This factor alone gives the sea-going form a distinct advantage and, all else being equal (and assuming the two forms breed true), over time the sea-going form should come to dominate any stream system with migration connectivity to the ocean. The resident forms would become confined to streams that lack migration connectivity. This pattern has been observed, for example, in the Deschutes River in Oregon (Zimmerman and Reeves, 2000).

In southern California, three ecological factors could potentially counteract this size advantage, so that the resident form is sometimes favored in anadromous waters. First, the migration corridor could be unreliable. Second, mortality may sometimes be much higher in the ocean than in freshwater, counter-acting 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? Migration corridors in this arid region are clearly unreliable, but it is not clear precisely how reliable they must be for the anadromous form to persist over the long term, nor how to best characterize reliability.

Recommendation: The relationship between flow patterns in managed rivers, the reliability of migration opportunities, and the long term persistence of steelhead runs is likely to be watershed specific, but could be characterized through the establishment of a long-term monitoring effort that tracks abundance and timing of steelhead runs, and the timing of smolt runs, in specific watersheds of interest. This would provide a framework by which management actions, in the form of managed flow regimes, could be related to outcomes, in the form of migrant abundance and timing. However, answers would probably emerge only over the long term, and numerous confounding factors would also need to be taken into account by the monitoring framework.

13.3.3 Steelhead-Promoting Nursery Habitats

Question: What nursery habitats promote rapid growth rates of juveniles and therefore larger size at the time smolts emigrate to the ocean?

Another factor that might counter-act the fecundity advantage of steelhead over rainbow trout is low marine survival, which if small enough could cancel-out or even outweigh the fecundity advantage. For example, with a steelhead female produces about 3.5 times more eggs than a rainbow trout female, if mortality during the first year in the ocean is 3.5 times greater than the mortality of trout staying in freshwater, the fecundity advantage of the steelhead would, on average, be erased. Mortality that is higher—say, 10 times higher than in freshwater—would favor the freshwater form outright. In reality, the fact that the freshwater-resident and the ocean-going forms both occur in the region suggests that conditions sometimes favor one phenotype, and at other times favor the other.

Ocean survival varies among salmonids, ranging from 25% to below 1% (Logerwell *et al*., 2003; Peterson and Schwing, 2003; Ward 2000; Welch *et al.,* 2009). It would seem that 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 (Ward *et al*., 1989; Bond, 2006). Thus their growth opportunities in freshwater may influence their subsequent marine survival.

The most complete data on this phenomenon are from the Keough River steelhead population in British Columbia (Ward, 2000; Ward *et al*., 1989), reproduced here in Figure 13-2. According to Figure 13-2, an outgoing smolt that has a fork length of 14 cm has about a 3% chance of surviving to spawn, but a 16.5 cm smolt's chances are at least 3½ times better (*c.* 10%), and a 22 cm smolt's chances are an order of magnitude better (37%). Thus, mortality effects of size at ocean entry can be of the same order as the aforementioned 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) in Scott Creek in Santa Cruz County, which is much closer geographically to southern California. However, the average marine survival was observed to be lower, on the order of 3% rather than the 10% to 20% observed in the Keogh River population. Thus the line in Figure 13-2 would presumably have a similar slope, but be displaced significantly downward. In any case, 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.* [3]

Overall, this suggests that the recovery prospects for steelhead runs would be significantly improved by identifying, restoring, and protecting those freshwater habitats that tend to produce large smolts. 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).

To produce rapidly growing juvenile fish, a habitat must produce abundant food. Although young steelhead feed mostly on invertebrates, food productivity ultimately traces down the food chain to the primary productivity of plants, which require sunlight and nutrients. Sunlight can also heat up streams rapidly, and in southern California the streams cool enough for steelhead are mostly well-shaded, which precludes high levels of primary productivity (but can also result in increased allochthonous carbon inputs, including invertebrate food items, associated with riparian vegetation). One would expect that where steelhead nursery habitats exist, they embody some mechanism that allows cool water temperatures and high primary productivity to co-exist during the summer growing season. This appears to be the case of the Scott Creek population, in which the seasonal lagoon at the creek's confluence with the ocean serves as steelhead nursery habitat (Bond, 2006).

[3] 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.

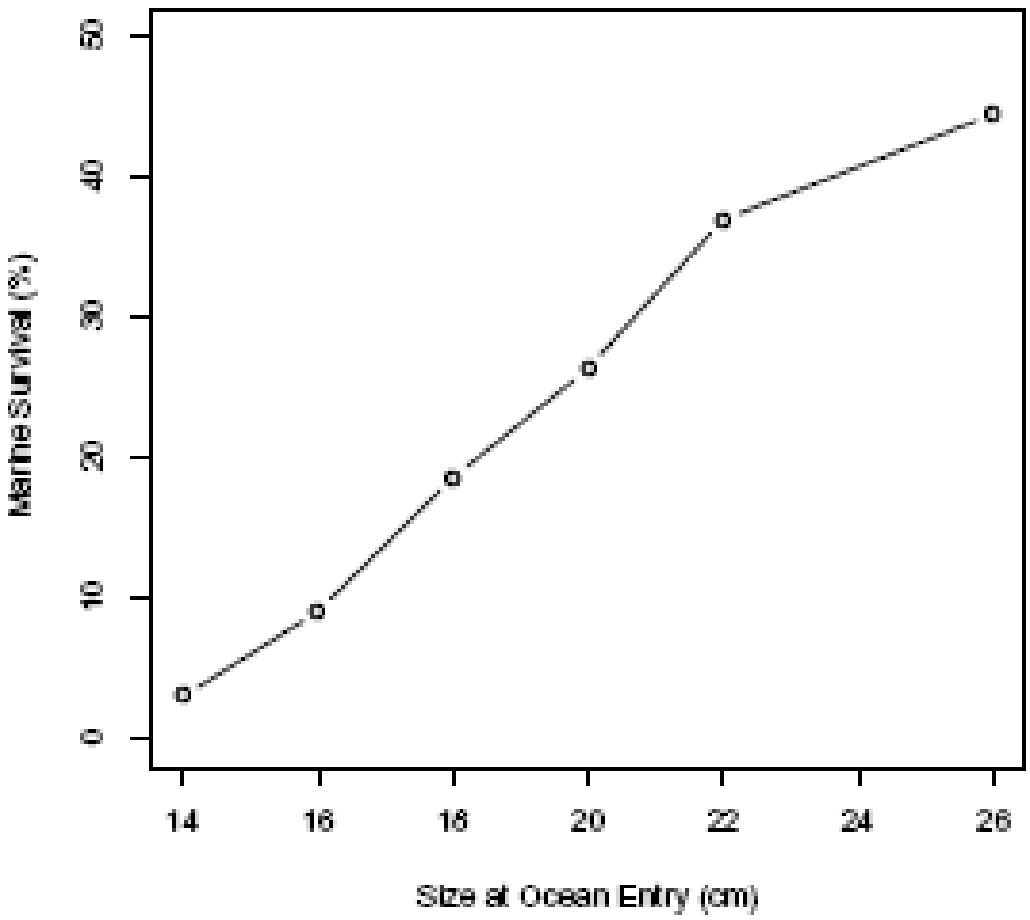

Figure 13-2. Marine survival of steelhead as a function of body size at ocean entry, in the Keogh River steelhead population described by Ward et al. (1989). Shown are the average survival to spawning of smolts emigrating in years 1977 - 1982.

Alternatively, steelhead nursery habitats might develop where cool-water habitats receive large terrestrial inputs of food items. Terrestrial insects often fall in the water (Douglas *et al.,* 1994; Harvey *et al.,* 2002), and can provide a significant component of the diet of young steelhead (Rundio and Lindley, 2008). The study by Rundio and Lindley (2008) in the Big Sur area found terrestrial insects were a sporadic occurrence in the diet of *O. mykiss*, but each item had large mass and thus was highly profitable to the fish. Habitats with more frequent inputs of terrestrial insects might offer large growth opportunities.

Finally, some habitats might produce rapid growth if there is a mechanism to keep juvenile densities low, so that individuals have expanded feeding opportunities. For example, it might be the case that intermittent streams provide expanded feeding opportunities during their wet season, because their dry season prevents the establishment of a large permanent population of resident rainbow trout.

Recommendation: The identification and restoration of steelhead nursery habitats is a prime research opportunity with large potential enhancing for steelhead recovery efforts. Nursery habitats would likely be estuarine or freshwater habitats that support rapid growth of young fish during the first or possibly second year of life, since large body size of migrants at ocean entry substantially improves their subsequent survival in the ocean. The simplest type of study to identify such habitats would be to use mark-recapture techniques to track growth and survival of juveniles as a function of habitat use. A more complete study would also track the consequences for marine survival.

13.3.4 Comparative Evaluation of Seasonal Lagoons

Question: What role do seasonal lagoons play in the life history of steelhead, and in particular, to what extent are seasonal lagoons used as nursery areas and promote the growth of juveniles prior to emigration to the ocean as smolts? What specific ecological factors contribute to lagoon quality (survival, growth) for steelhead rearing? What ecological factors contribute to lagoon reliability?

One type of steelhead nursery habitat is the freshwater lagoons that form in the estuaries of many stream systems during the dry season. In some of these seasonal lagoons, juvenile steelhead can grow very quickly and enter the ocean at larger sizes, where they survive relatively well and thus contribute disproportionately to returning runs of spawners (Bond, 2006). Smith (1990), however, has observed that some lagoons can be quite vulnerable to rapid degradation in quality, and others may never be suitable, due to local environmental factors that can produce anoxic conditions or poor feeding opportunities. The existing information on the role of lagoons mostly comes from Santa Cruz County, focusing 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). So there is a need to determine which lagoons have the potential to play a positive role in anadromy-targeted recovery efforts.

Seasonal lagoons are a specific kind of estuary, and in general estuaries are highly dynamic interfaces between two other much larger ecosystems: freshwater stream networks on the terrestrial side, and the ocean ecosystem on the marine side. This accounts for estuaries' dynamism, complexity, and sensitivity to external influences, but also for much of their productivity (Hofmann, 2000; Jay *et al.*, 2000). Although there appears to be a general unity in function of many of the small estuaries in our region (due to the general similarity of climate, terrestrial watershed conditions, and the raised coast), there is also much variation and one would expect that small differences in, say, watershed condition or coastal wind and current patterns would sometimes translate into large differences in the suitability of lagoons as steelhead nursery habitat (Rich and Keller 2009).

Recommendation: Comparative studies on the environmental controls for productivity and reliability of lagoon habitat (including how to restore it if necessary) would aid in identifying those estuaries capable of serving as reliable steelhead nursery habitat. Such studies should focus on factors enabling rapid growth of juvenile steelhead, and factors conferring resiliency against catastrophic failure of habitat quality (anoxia, premature breaching, *etc.*).

13.3.5 Potential Nursery Role of Mainstem Habitats

Question: What role do mainstem habitats play in the life history of steelhead, and in particular, to what extent are they used as nursery areas and promote the growth of juveniles prior to emigration to the ocean as smolts? What specific ecological factors contribute to mainstem quality (survival, growth) for steelhead rearing? What ecological factors contribute to mainstem reliability?

There may be other freshwater habitats that support high survival and robust growth of juveniles, and so constitute nursery habitat specifically for the anadromous form of the species. Low-gradient mainstem habitats, such as the trunks of the Santa Ynez, Ventura, Santa Clara, and Pajaro Rivers, may also have once supported rapid growth of juveniles, particularly if reaches received enough sunlight to support primary productivity, but artesian flows or other groundwater inputs kept water cool in the summer (C. Swift, personal communication). Most mainstem habitats have now been highly altered by agricultural clearing and groundwater pumping, so an effort to determine their upside potential for steelhead recovery would require some effort.

Recommendation: The potential nursery role of mainstem habitat is much more speculative than the nursery role of lagoons. Initial assessment of the potential nursery role could take the form of 1) empirical study of mainstem habitat use by juvenile steelhead, at broad and fine scales; and 2) water-temperature modeling that accounts for effects of climate, insolation, and groundwater interaction on mainstem water temperatures, especially during the summer. The empirical work would be most useful if it applied mark-recapture techniques to assess growth and survival as a function of habitat use, and in managed rivers, as a function of the flow regime.

13.3.6 Potential Positive Roles of Intermittent Creeks

Question: Do intermittent creeks serve as steelhead nursery habitat, positively influence the anadromous fraction of *O. mykiss* populations, or otherwise enhance viability of the anadromous form of the species?

Juvenile *O. mykiss* are common in intermittent creeks (Boughton 2008), but it is unclear whether these simply function as sink habitat (a net drain on productivity) or play a more positive role in population viability. Boughton (2008) observed that, during the early summer in a moderately wet year, densities of young-of-the-year *O. mykiss* were nearly identical in the perennial and intermittent creeks of the Arroyo Seco watershed in Monterey County. Much of the intermittent creeks dried up and killed juveniles later in the summer, and indeed such mortality has been observed in the region for many years (Shapovalov, 1944), although it is also common to find scattered residual pools or reaches packed with fish in late summer. For example, Spina *et al.*, 2005 observed fish in San Luis Obispo creek moving into sections of the stream network retaining perennial flow as other streams dried out over the summer months. The important issue is identifying the potential positive, rather than negative, roles of intermittent creeks in sustaining the viability of steelhead populations.

- The most obvious positive role is that intermittent creeks provide migration corridors to perennial creeks during the wet season. Perennial reaches often occur in low-order

streams upstream of intermittent sections, so the corridor role increases the amount of accessible perennial habitat, and thus the size of the steelhead population that can be supported. In dry years, the corridor function would fail in some areas.

- Boughton (2008) found that most spawning habitat in the Arroyo Seco system tended to occur in intermittent streams, and argued that hydrologic and geomorphic processes would tend to produce such a pattern in general. This suggests a second positive function of intermittent streams—significantly expanding the amount of spawning habitat beyond what is available in perennial streams—but it also suggests a need for an additional corridor function. In this case, the corridor function is for young-of-the-year to emigrate to perennial reaches before the summer dry season traps and kills them.

- It is possible that intermittent streams enable a high-risk, high-reward strategy on the part of young steelhead. Many individuals may be killed during the summer drying season, but those surviving in the residual pools may benefit from enhanced growth. One mechanism for enhanced growth may be cannibalism of trapped cohorts. Another mechanism for rapid growth may be rapid recolonization of the dried stream channels as flows become re-established with cooler, wet weather in the fall.[4] Such would find few competitors, and perhaps even an enhanced opportunity to feed on eggs and fry of the following winter's spawners (Ebersole *et al.*, 2006). In this manner, intermittent creeks could serve as steelhead nursery habitat

- In wet years, the seasonal drying may be substantially reduced, increasing summer survival and allowing large pulses of juveniles to be recruited to the subpopulation of adult steelhead in the ocean. Under some scenarios, such as a highly plastic life-history strategy (see next section), it is possible that such pulses would be the primary mode of production for anadromous individuals, and sustain the anadromous form of the species over the long term.

Recommendation: Intermittent creeks comprise a large proportion of freshwater *O. mykiss* habitat in the region. Despite an obvious negative role in the species ecology, they may have important positive roles as well. These potentially positive roles have the status of hypotheses with general implications for recovery strategies and viability targets, and should be tested.

[4] Fall rains can re-establish flows, but flows may also be re-established by cooler fall weather, which presumably lowers transpiration demands of riparian vegetation, leaving more groundwater to maintain base flows in stream channels.

13.3.7 Spawner Density as an Indicator of Viability

Question: At what density can a spawning habitat be considered saturated?

This question directly addresses one of the viability criteria—spawner density—that was thought necessary to achieve resilient populations, but that has not been characterized for steelhead in general or southern steelhead in particular.

Recommendation: Monitor a select number of core and non core populations to determine the numbers of spawners using both mainstem and tributary spawning habitats. 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.

13.3.8 Uncertainty about Population Structure

Population structure concerns the ecological and biological factors that cause fish to naturally group into functional units known as independent populations. Independent populations are defined as "a collection of one or more local breeding units whose population dynamics or extinction risk over a 100-year time period is not substantially altered by exchanges of individuals with other populations" (McElhany *et al*., 2000).

If groups of fish regularly exchange individuals, they are members of the same population, whereas if exchange is rare or does not significantly affect population dynamics, they are members of separate populations. This definition of "separateness between, exchange within" means that the proper context of most management strategies is the independent population: a strategy that directly affects only a portion of a population will soon have significant indirect effects on the rest of the population, but few immediate effects on other populations. [5]

The independent population is also the fundamental functional unit of species persistence, and hence viability. As a result, many of the viability criteria described by Boughton *et al.* (2007) were defined in terms of population traits such as anadromous fraction and mean spawner abundance over time. The collections of fish to which these criteria should be applied are a function of what is known about the patterns of exchange of fish among breeding biological units. Open questions about such exchange result in uncertainty about how to apply the criteria.

Thus, an analysis of a simple quantitative model led Boughton *et al*. (2007) to conclude that an annual adult abundance of 4,150 fish were necessary for an independent population to be considered viable. But it was unclear, due to questions of exchange patterns, whether the criteria should be applied to:

- anadromous fish in a particular watershed, or
- the sum of anadromous fish across several watersheds, or
- the sum of anadromous and freshwater-resident fish in a particular watershed, or

[5] Over the longer term, a permanent change in population dynamics *would* be expected to trickle out to other independent populations, due to occasional exchanges of individuals. Occasional exchanges are expected to drive important processes such as gene exchange and recolonization of stream systems following a drought.

- the sum of anadromous and freshwater-resident fish across several watersheds

The answer has implications for the scope and scale of recovery efforts. The answer depends on the level of exchange of fish across separate coastal watersheds, and on the level of exchange between the anadromous and resident forms of the species within a particular watershed—termed 'life-history crossovers". A life-history crossover is a freshwater parent that has anadromous fish among its progeny, and/or vice versa. Questions about inter-watershed exchanges and life-history crossovers, and the implications for viability criteria, are key issues addressed in this section.

13.3.9 Partial Migration and Life-History Crossovers

Partial migration is the phenomenon in which a population consists of both migratory and resident individuals (Jonsson and Jonsson, 1993), implying the regular or at least occasional occurrence of life-history crossovers. A diversity of crossover patterns have been observed in the small number of studies conducted on *O. mykiss* to date. Zimmerman and Reeves (2000) observed no crossovers in resident and anadromous *O. mykiss* of the Deschutes River in Oregon, implying two demographically distinct (independent) populations. For one natural and eight hatchery populations in California, Donohoe *et al.* (2008) found that anadromous females sometimes produced resident progeny, but resident females did not produce anadromous progeny, suggesting a one-way flow of crossovers away from the anadromous form.

The Babine River *O. mykiss* in British Columbia apparently exhibit modest levels of crossover (*c.* 9%) in both directions (Zimmerman and Reeves, 2000), suggesting a single population that is partially subdivided, whereas J.R. Ruzycki (personal communication in Donohoe *et al.* 2008, p. 1072) reports a high level of bidirectional crossover in various tributaries of the Grande Ronde River in Oregon (0% to 33% of anadromous adults were progeny of resident females, and 44% of resident adults were progeny of anadromous females), indicating a fully integrated population in which the two life-history forms functionally co-exist.

This continuum has significant implications for viability criteria. Are the populations in southern California fully integrated, or does each form more or less breed true, implying demographically independent populations that share stream systems but play no role in supporting one another, and perhaps even compete? Boughton *et al.* (2007) made recommendations that embodied these two possibilities (actually two endpoints of a continuum). On the one hand, one should specify criteria that would secure the ocean-going fish if they turn out to comprise a demographically independent population. On the other hand, one should specify criteria that secure the ocean-going fish if they turn out to depend on the resident form with which they coexist. However, it is possible that resolution of the uncertainty would eliminate some of the need for hedging and thus lead to a more efficient and effective recovery plan. Resolution would involve two fundamental questions:

Question 1: What is the mechanism for, and frequency of, life-history crossovers in southern California?

Question 2: How does crossover affect the persistence of the anadromous form?

Answering the first question will take an extended research effort. Currently, S. Sogard (NOAA Fisheries) and M. Mangel (UC Santa Cruz) are leading a research effort to better understand life-history crossovers in California steelhead; Mangel and Satterthwaite (2008) give an overview of the framework being used. The hypothesis being examined is that the anadromy/residency life-history crossover made by individual *O. mykiss* is cued by the environment, using a mechanism similar to what has been observed in Atlantic salmon (*Salmo salar)*, a better-studied species that also exhibits variation in the timing of the smolting decision 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.

Though the research effort of Sogard and Mangel is important progress on the anadromy/residency life-history crossover phenomenon in steelhead recovery planning, it has important limitations at this time. First, it has the status of a hypothesis and at this writing no one has actually experimentally induced life-history crossovers in *O. mykiss* by manipulating size or growth rates or any other environmental factor. Second, even if the Atlantic salmon model is useful for understanding life-history plasticity in *O. mykiss*, there are almost certain to be important differences and indeed surprises in the *O. mykiss* story. It would be surprising if there were no surprises. Finally, the existence of a plastic life-history strategy does not preclude the possibility of important genetic constraints. For example, one might expect that even if the model is broadly correct, the specific timing of sensitive periods, and the thresholds for the size and growth cues, would probably vary quite markedly among populations of steelhead due to genetic differences. In short, the responses to environmental cues would likely have a heritable component, and this component would likely exhibit local adaptation to specific conditions. A response that is adaptive in one watershed may be selected against in another watershed, depending on environmental factors such as those discussed in the previous section.

Recommendation: It is essential for the research effort on the mechanisms of life-history plasticity in *O. mykiss* to pursue a rigorous research effort, for it is difficult to envision a successful recovery effort without a better understanding of the functional relationship between resident and anadromous fish. The current effort of Sogard, Mangel, and coworkers should yield useful information over time, but it focuses on two systems outside southern California: Soquel Creek in Santa Cruz County (a coastal redwood forest system), and the American River near Sacramento (a large Central Valley River system). One should expect local adaptation of steelhead populations in the southern California.

Because of local adaptation, it might be useful and practical to address some related questions about the frequency of life-history crossovers and their implications for recovery planning in the southern California. In particular:

- Identify environmental factors that specifically promote anadromy (discussed in the previous section). It is clear that the abundance of anadromous fish needs to be increased, and identifying relevant environmental factors would usefully inform this goal. The principal uncertainty is how much the abundance of anadromous fish needs to be increased, a separate question that depends on the frequency of life-history crossovers and the mechanisms underlying them. This question can be addressed over the longer term as more is learned about the mechanism, and used to refine the viability criteria described by Boughton *et al.* (2007).

- Estimate the frequency of life-history crossovers in populations of interest, to determine whether it even occurs with any regularity. The most practical method for doing so is by analyzing otolith microchemistry of juvenile *O. mykiss* (see Donohoe *et al.,* 2008), but unfortunately this requires lethal sampling of juveniles. Modest lethal sampling of juveniles (as opposed to adults) is likely to pose only a negligible increase extinction risk, due to the low reproductive value of juveniles (most sampled juveniles would die in nature before reaching reproductive age).

- Determine how life-history crossover affects the persistence of the anadromous form. This could be done using existing frameworks in population modeling, such as individually-based models or integral projection models, but would require assumptions about typical mortality and growth rates in freshwater and marine environments, as well as about frequency of life-history crossovers. However, it might produce important insights. For example, persistence of anadromous runs could be strongly affected by the difference between complete lack of crossovers and a modest rate, such as 5%. However, effects would be much smaller between a 10% rate versus a 50% rate. It would be useful to more rigorously evaluate the validity and relevance of these levels of life-history crossovers.

13.3.10 Rates of Inter-Watershed Exchange

Question: How common is inter-watershed exchange, and how does it relate to population structure, especially in small coastal watersheds?

Just as life-history crossovers may knit resident and anadromous *O. mykiss* into integrated populations, frequent movement of anadromous fish through the ocean to neighboring watersheds may knit neighboring *O. mykiss* into integrated "trans-watershed" populations. If inter-watershed exchange is common, the most effective recovery strategies might be those that emphasize integration of recovery efforts across a set of linked Watersheds. If inter-watershed exchange is rare, the most effective strategies would be those that identify watersheds having stable conditions that protect small, inherently vulnerable populations.

The places where the implications of the single-watershed versus trans-watershed scenarios are most distinct are those areas along the coast where numerous small coastal watersheds occur in close proximity. These areas are the Big Sur Coast, the coast of San Luis Obispo County, the south coast of Santa Barbara County, and the small watersheds draining the Santa Monica Mountains just north of Los Angeles.

Recommendation: Answering this research question will involve tracking the populations from multiple watersheds, including groupings of small, closely spaced watersheds as well as groupings involving large and small watersheds more spatially dispersed. However, it is not clear at this time what is the most practical and effective way to try to estimate exchange rates in the recovery planning area. Genetic tags and ecological traps may have potential to effectively address this question and should be explored.

13.3.11 Revision of Population Viability Targets

In the framework described by Boughton *et al.* (2007), the key criteria for establishing population viability was that a population be demonstrated to sustain a long-term mean run size of at least 4,150 anadromous spawners per watershed per year. However, the authors noted that the criteria were chosen to be precautionary due to scientific uncertainty about key issues, and that better information might allow the criteria to be revised without increasing the risk of extinction. There were three types of information that seemed most likely to lead to useful revisions of the viability criteria:

1. The threshold run size might be able to be revised downward from 4,150 spawners per year if it was determined that year-to-year variation in run size was modest enough to be consistent with a lower threshold. The necessary information—annual estimates of run size over several decades—would come from the types of monitoring programs described below.

2. Data on the frequency of life-history crossovers might justify that the 4,150 threshold could include some fraction of adult resident fish, rather than the 100% anadromous fraction currently recommended (*i.e.* because the resident and anadromous forms are shown to comprise functionally integrated populations). The necessary information would come from successfully implementing the recommendations identified above.

3. Data on inter-basin exchanges might justify that the 4,150 threshold include spawners from neighboring watersheds (*i.e.* because inter-watershed exchanges is sufficiently high that the fish in neighboring watersheds comprise a single, trans-watershed population). The necessary information would come from successfully implementing the recommendations identified above.

It should be noted that data for item 1 would arise over time as a byproduct of a comprehensive monitoring program, which is necessary to assess risk in any case. The priority item, however, is probably item 2, since the integration of the resident and anadromous forms is not well understood, but has profound implications for a very diverse set of management issues beyond just revision of recovery criteria.

13.3.12 Planning for Climate Change

The addition of CO_2 and other greenhouse gasses to the atmosphere over the past two centuries, as a side effect 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 for millions of years. Regional climate projections for the south-central and southern California coast ranges suggest a future of longer, hotter summers, more extreme heat waves and droughts, perhaps drier rainy seasons, and perhaps more intense precipitation events in some areas (Snyder *et al.*, 2002; Bell *et al.*, 2004; Bell and Sloan, 2006; Snyder *et al.*, 2004; Snyder and Sloan, 2005; Karl, *et al.* 2009). Regarding the marine environment, the California Current ecosystem is likely to respond by warmer conditions and a delayed upwelling season, which would likely have detrimental effects on steelhead, but a more intense pattern of upwelling during the summer which would potentially have beneficial effects on feeding opportunities. (Schwing *et al.*, 2009).

A review of existing studies indicates that regional changes in the physical setting will almost certainly drive ecosystem changes in a diverse and intricate ways (Schwing *et al.* 2009). The ability to model and forecast the effects of such changes on steelhead populations is likely to be quite limited due to well known limitations on the predictability of behavior of non-linear causal networks. (Schindler *et al.*, 2008). This problem is common to many threatened species, but is especially exacerbated for Pacific salmonids due to their requirements for a succession of different habitats over the course of their life history. However, the environmental changes expected for southern steelhead are not as profound as elsewhere such as Central Valley, where populations dependent on snowmelt-fed river systems are facing a type–conversion to rain-fed system, or coastal coho populations which have a fixed life-history strategy that may be less adaptable to environmental changes than steelhead (Moyle, *et al.*, 2008). The changes in the physical setting in southern California are expected to mainly intensify patterns that are already typical (drought, intense cyclonic rainstorms, dry, hot summers), and to which the local populations of steelhead appear to have already evolved a flexible, opportunistic strategy for survival.

While some physical parameters of climate change are likely to be predictable, the response of ecosystems and hence the future conditions of steelhead habitats are must less predicable. This suggest that he over-arching strategy for dealing with climate changes will be to enhance the resilience of the steelhead metapopulations to respond to ecosystem changes in genera., through forecasting and managing the physical habitat envelope of the species according to a few core principles (see Boughton *et al.*, 2009 for a discussion of these principles):

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

For recovery efforts to succeed in the long term, they will need to focus on watersheds that will be suitable for steelhead populations under the new, future climate. Some of the issues and research needs involved in identifying those watersheds expected to be suitable for steelhead populations in the future are discussed below.

13.3.12.1 Viability Criteria and Climate Change

The viability framework (Boughton *et al.,* 2007) laid out a set of criteria for ensuring representation and redundancy of viable steelhead populations across a set of biogeographic regions in the study area. This was based on two kinds of information:

1. Information on the historical occurrence of steelhead populations in watersheds, based mainly on records of the species' occurrence from the latter half of the 20th Century, and

2. Information on the extent of potential summer habitat, modeled from basic topographic and hydrographic data on the region's stream networks, recent hydrological data, and the climate of the period 1960 - 1990.

The purpose of viability criteria at this regional level is to ensure persistence of steelhead at a timescale of thousands of years. However, the criteria did not explicitly incorporate the implications of climate change, which has the potential to render some watersheds unsuitable for steelhead. Rather, the criteria focused on risks stemming from three sorts of natural catastrophic events or processes, all of which can be significantly affected by climate change:

Wildfires. The level of redundancy in the criteria was intended to protect against catastrophic loss of steelhead populations from the effects of wildfires to ensure that at least one population would survive an extreme year of wildfires in any biogeographic region. The level of redundancy chosen was based on the historical pattern of wildfires in the region, but was also based on conservative ("worst-case") assumptions about the short-term negative effects of wildfires on steelhead populations. This protects against our current lack of understanding about such effects, but also may perhaps tend to protect against future changes in the wildfire regime due to climate change. However, if wildfire frequency increases too much, it is likely to lead to wholesale conversion of chaparral ecosystems into grassland ecosystems, with implications for steelhead populations that are not accounted for in the current viability framework. Some of these implications may be positive: grassland conversion has been proposed to concurrently convert intermittent streams into perennial streams (Keeley, 2002). Other implications are negative: for example, if increased frequency of wildfires is coupled with periods of drought and heat, or if winter storms become more intense, exacerbating the sedimentation problems unleashed by wildfires. Also, with respect to wildfire risk, the criteria treated watersheds as exchangeable within biogeographic groups—no stream system was considered to be more buffered or resistant to the detrimental effects of wildfire compared to any other. If wholesale change in the fire regime occurs under climate change, it might be necessary to change the focus from achieving simple redundancy to identifying any stream systems that are inherently buffered against the effects of climate change on wildfire (as with the case of drought; see below).

Landslides. Existing evidence suggests that the most extreme episodes of land sliding tend to occur in recently burned watersheds. The TRT thus concluded that a level of redundancy that protects against extreme wildfire years would also protect against extreme land sliding events. There does not appear to be any obvious way in which climate change would change the extreme episodes of land sliding through a pathway other than the wildfire regime. One additional possible mechanism is an increase in the maximum intensity of storm systems, though existing

regional climate projections are equivocal about this possibility (Bell *et al.*, 2004; Bell and Sloan, 2006). However, land sliding is only one particularly catastrophic element in the overall sediment dynamics of the stream networks of our area, and there are many ways in which climate change may impact the sediment regime, either to the detriment or the benefit of steelhead populations. Again, rather than treating all watersheds as having exchangeable risks, an attempt could be made to identify those in which climate change will have either neutral or beneficial effects on the sediment regime, as judged by changes in the extent, reliability, and connectivity of steelhead habitat.

Droughts. The viability report (Boughton *et al.*, 2007) indicates that redundancy in and of itself is not a useful strategy for dealing with the catastrophic risks posed by drought. The reason is that the spatial extent of the typical drought exceeds the geographic range of the steelhead DPS southern in southern California, so all steelhead populations will be exposed to drought under a typical scenario. Thus, the research need stated in the report was to identify watersheds that are resistant to the negative effects of drought on steelhead habitat. In view of projected climate change, this research should be expanded to identify possible watersheds that are expected to be resistant to the negative effects of drought under the new climate regime.

The common thread is a need to focus on the heterogeneity in various watersheds' responses to climate change, and identify if possible those watersheds that are most likely to be suitable for steelhead in the future climate. In addition to wildfires, landslides, and droughts, climate change is likely to influence habitat suitability for steelhead through a variety of other pathways as well. Extremes of summertime air temperatures will increase, in some areas more than others. Extremes of winter streamflows and stream power will change, with implications for channel structure and the distribution of spawning areas. The climate trajectory may drive changes in wildfire and vegetation that influence patterns of stream shading and, via plant water use, the water available for summer base flows (*e.g.*, Tague *et al.*, 2009). In addition, there will be gradual sea level rise that inundates estuaries, and possible effects on marine upwelling patterns (Snyder *et al.*, 2003; Diffenbaugh *et al.*, 2004).

13.3.12.2 Extending a Coastwide Climate Assessment Effort

There is currently a coastwide effort to assess and rank the responses of salmon and steelhead populations to climate change, which is consistent with the need just identified, to focus on the heterogeneity of watershed response in our particular region. The effort is being conducted by a set of working groups at the National Center for Ecological Analysis and Synthesis in Santa Barbara, and is known as the Prediction of Responses of Wild Pacific Salmon to Climate Change.

When the working Groups completes their tasks as described above, the results will be useful for refining the recovery priorities of steelhead trout in southern and south-central California. However, since the groups' effort is coast-wide, its findings for southern California may be too coarse to identify the greatest opportunities for effective recovery actions. This is because such opportunities may often be in watersheds whose response to global warming is exceptionally benign to steelhead, rather than typical. In a broad scale assessment, it is the typical response of watersheds that will most likely be characterized, whereas for the actual situation it may be necessary to identify specific idiosyncratic or unusual departures from the norm in order to effectively protect steelhead. For example, Bean (2007) has found that the juxtaposition of two

particular rock types in the Santa Ynez Mountains, with faulting parallel to the general courses of coastal streams, is responsible for maintaining suitably reliable and cold base flows in many streams. This sort of region-specific pattern would easily be overlooked in a coast-wide assessment of climate impacts, but would be critical at a local scale.

As a result, there will likely be necessary to extend the results of the working groups, when they are completed. The following questions of particular importance have already been identified by the TRT:

- How will the climate trends alter the wildfire regime, and thus alter sedimentological and hydrological processes that effect the distribution of steelhead habitat?

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

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

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

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

- Flood and drought regimes have been highly episodic, were even more so in the 19th Century, and may become even more so under future climate patterns. What are the implications for steelhead population viability?

The following table provides a summary of the various processes and features of freshwater habitat which have the potential to be affected by global climate change.

Table 13-1. Levels of Organization in Freshwater Steelhead Habitat Response to Climate Change

Global Climate
New regional means in temperature, rainfall
Rainfall intensity
Drought occurrence

Regional Climate
Interactions with landforms
Effects of ocean, upwelling
Fine-resolution temperature, rainfall, intensity

Watershed Response

Vegetation evapotranspiration and CO2 enrichment
Long-term response of vegetation structure
Runoff and groundwater recharge
Erosion, sediment delivery to channels
Wildfire regime, affects on runoff and erosion

Fluvial Hydrology/Geomorphology
Peak flows and stream power
Distribution of spawning gravels
Distribution of pools, roughness elements
Distribution of perennial streams
Riparian vegetation: structure, transpiration
Dry-season baseflows
Summer water temperatures
Migration opportunities
Inundation/aggradation of lagoons
Changes to lagoon barring and mixing patterns

Ecosystem Response
Macro invertebrate production
Invasion by predatory fish
Invasion by exotic competitors, predators, pathogens
Riparian shading
Terrestrial inputs of macroinvertebrates

13.4 MONITORING PROGRESS TOWARD RECOVERY GOALS

Monitoring should be conducted for each BPG, with monitoring initially focused on Core 1 populations. As described by Boughton *et al.* (2007), the general goal of recovery is to establish a diverse and geographically distributed set of populations, each of which meets viability criteria over the long term. These viability criteria are expressed in terms of mean annual runs size, persistence over time, spawner density, anadromous fraction, as well as the continued expression of life-history diversity, and the spatial structure of the population. Strategies for monitoring these properties of steelhead populations over the long term are essential for assessing the attainment of recovery goals.

13.4.1 Strategy for Monitoring Steelhead in Southern California

Southern California 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 Boughton *et al.* (2006). The strategy described below considers these factors, as well as the spatial and temporal distribution of southern California steelhead. The basic components of the southern California steelhead monitoring strategy include:

1. Reconnaissance surveys and assessments of steelhead populations.

2. Reconnaissance surveys and assessments of riverine and estuarine habitat conditions.
3. Counting stations stratified at both the BPG and population levels.
4. Life-cycle stations (LCS) stratified at both the BPG and population levels.

Currently there is no current comprehensive assessment of the condition and distribution of steelhead populations and habitats in southern California that use standard population and habitat assessment protocols. The monitoring strategy includes an, initial assessment both of the fish populations and habitat condition. Assessments should initially focus on Core 1 populations in each BPG, ultimately include all populations which are necessary for full recovery of the species. Stream habitat assessments should be conducted using the protocol in the California Department of Fish and Game's California Salmonid Stream Habitat Restoration Manual (California Department of Fish and Game 2009).

Counting stations comprised of fixed structure utilizing technologies such as DIDSON cameras, are the most effective means of establishing abundance and trends of adult anadromous runs of steelhead and juvenile out migration. County stations should initially be located in Core 1 populations in each BPG.

Life-cycle monitoring can be co-located with county stations, but may also be conducted in one or more of the non-core populations which support smaller but less impacted populations. LCSs monitoring efforts provide the foundation for evaluating the relationship of fish habitat use and habitat condition over time and should focus on:

1. Estimation of marine and freshwater survival
2. Spawning success (spawning ground distribution, redd to adult ratio)
3. Juvenile rearing success (over-summering and winter growth)
4. Major life-history traits (anadromy/resident relationships, sex ratio, age and size structure, habitat utilization patterns, emigration age and timing, maturation patterns, run-timing, and physiological tolerances)

These LCSs could also be used in evaluating nutritional needs, predation, disease, and other environmental factors relevant to assessing the status of individual populations. Where permanent LCSs are not established, temporary stations should be deployed to maximize the development of populational information in Core 1, 2, and 3 watersheds.

Table 13-2 lists the preliminary sites where counting stats and LCSs should be established. LCS sites should be sited based on two criteria: their relation to the BPG and whether they are necessary to represent the full range of watershed types for each BPG.

Table 13-2. Potential Southern California Steelhead Life-Cycle Monitoring Stations (alternative populations are listed in parentheses).

Life-Cycle Monitoring Station	Population	Potential Location
1	Santa Maria River	Below Sisquoc
2	Santa Ynez River	Bradbury Dam
3	Ventura River	Robles Diversion
4	Santa Clara River	Vern Freeman Diversion
5	Mission Creek (Arroyo Hondo Creek)	Below Rocky Nook Park
6	Carpinteria Creek	Above Highway 101
7	Rincon Creek	Above U.S. Highway 101
8	Malibu Creek (Arroyo Sequit, Topanga Creek)	Below Rindge Dam
9	San Gabriel River	Below Morris Dam
10	San Juan Creek	Below Metro-link Crossing
11	San Mateo Creek	Above Highway 1
12	San Luis Rey River	Below Bonsall

To the maximum extent possible, monitoring the status and trends of steelhead populations should be undertaken simultaneously with restoration efforts. Watersheds where restoration has or is occurring should be considered be considered a high priority for monitoring. Monitoring stations, whether counting or life-cycle stations, should serve as a magnet for research efforts depending on fish and fish related field data.

13.4.2 Monitoring Protocols

Below is a brief summary of potential methods to monitor run-size of steelhead (number of anadromous spawners per year per population).

13.4.2.1 Counting at Fish Ladders

Fish ladders can provide important opportunities to count upstream migrants, assuming the fish passage facilities themselves provide effective unimpeded fish passage opportunities. There are a number of technical challenges in operating fish detection and counting devises in extremely flashy systems characteristic of southern California (see discussion below). Additionally, this method is only relevant to watersheds that have fish ladders, and cannot quantify the portion of the run that spawns below the fish ladder. Depending on the location of the ladder and the amount and type of habitat downstream of the ladder, the spawners below the ladder can be an important component of the run.

13.4.2.2 Redd Counts

Gallagher and Gallagher (2005) have shown that salmon and steelhead runs can be estimated using redd counts. A summary of their method and is provided below:

To estimate Chinook salmon *Oncorhynchus tshawytscha*, coho salmon *O. kisutch*, and steelhead *O. mykiss* escapement in several coastal streams in northern California a stratified index redd method was developed, based on the assumption that redd size is related to the number of redds a female builds. Due to temporal overlap in the spawning of these species in coastal northern California sources of error in redd counts were identified, through the use of logistic regression to classify redd species. Redd area escapement estimates were compared with estimates from more conventional methods and releases 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 tried in the southern California setting, where stream turbidity and channel geomorphology may make redds difficult to detect in difficult wintertime conditions. The method has high personnel requirements, because it requires the survey reaches to be visited biweekly throughout the spawning season. On the other hand, it is simple, requires only modest training in field personnel, and has modest costs other than the hiring of personnel.

13.4.2.3 Monitoring runs using the DIDSON Acoustic Camera

Dual-frequency identification sonar (DIDSON) is an off-the-shelf device that uses high frequency sound waves to produce near video-quality images of underwater objects. It can potentially be used to identify and count all migrating steelhead at some survey point in a stream system, for the entire spawning season. Its advantages are similar to those of using a weir to make counts, but has several additional advantages that are key: 1) There is no need for a weir or other device that impedes flow, and so fouling, destruction by high-flow events, etc., are not a major constraint; 2) It can see through turbid waters (unlike a regular video camera). These two traits appear well suited to the flashy, turbid conditions typical of southern 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 southern California. Currently, staff at the NOAA's' Southwest Fisheries Science Center are evaluating field methods for using the device to monitor steelhead runs in southern California streams.

The principal disadvantages are: 1) the cost of the device, and 2) deployment constraints for getting good images. These constraints have to do with maintaining a good "insonified region" of the channel being monitored for migrants. Some channel shapes are better than others, and there also need to be a strategies for maintaining a completely insonified cross section during the advance and retreat of high flow events. In addition, there is a need to learn how to interpret poor images when they occur. However, the method has the promise to solve some of the intractable problems of monitoring steelhead in southern California, including counting very small numbers of migrants in very turbid waters during and after very flashy high-flow events.

13.4.2.4 Tagging Juveniles and Monitoring Migrants (T-JAMM design)

Steelhead runs can potentially be estimated by tagging juveniles with Radio Frequency Identification (RFID) tags during their freshwater phase, and subsequently monitoring migrants using in-stream tag readers. The design has promise for monitoring runs of steelhead for which many other methods are problematic. In unpublished simulations, Boughton has found that the precision of run size estimates is primarily controlled by the number of tagged spawners that ultimately return and get detected. The number required is modest: around 30 to 90 tagged spawners are necessary to obtain 50% confidence intervals that stay below one-third of the estimated of run size. However, with marine survival typically falling between 0.3% and 3%, the required tagging effort would usually be between 3,400 and 45,000 juvenile fish tagged per generation per population to achieve this modest number of tagged spawners. Other considerations in using implanted tags are the mortality/fitness risks and the permitting requirements to allow some level of take of the species. The tagging effort could perhaps be spread across a set of populations if one were willing to assume uniform marine survival across the populations.

The estimation method is robust to imperfect detection of tagged fish by the instream tag readers, as long as there are at least two readers that independently scan for tags. Reach-sampling allows the entire run to be estimated using fish from a sample of reaches. In the simulations, the number of reaches needed for acceptable precision could be as low as 30-40 under scenarios of high

marine survival, a sampling fraction of around 2% in large watersheds, such as the Arroyo Seco watershed used in the simulations.

Under low marine survival, the necessary sampling fraction was around 10% in the simulations. A side-benefit of this method is that one would obtain very good estimates of ocean survival. This is useful because it allows the overall trajectory of steelhead runs to be decomposed into marine and freshwater components. This, in turn, will deliver greater statistical power for analyzing patterns in the freshwater component. In short, one would have greater statistical power for determining if recovery actions on the freshwater side are actually having the desired effect.

Boughton has written software to estimate run size from data produced by tagging juveniles and monitoring migrants. It is written in the R computer language, a freely-available statistical programming environment that is widely used in the scientific world. Currently the work is in manuscript form. Williams, Rundio, and Lindley of the 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 South-Central California Steelhead DPS.

13.4.2.5 Sampling Young-of-the-Year Otoliths (YOYO design)

This method is similar to tagging juveniles and monitoring migrants, but instead of tracking the fate of captured juveniles to estimate run size, one would collect some fraction of the juveniles, and examine their otoliths and genetic relatedness. From this, one could estimate the number of anadromous mothers (and as a byproduct, non-anadromous mothers) for each annual cohort of young-of-the year fish. This should be suitable for estimating annual run size, at least of female fish.

This method would dispense with the need to implant RFID tags in fish, and the need to maintain instream tag readers during difficult winter conditions. All field work would consist of eletrofishing juveniles at randomly-sampled stream reaches each summer. However, the method would require the time and expense of otolith analysis, and it would require collecting (*i.e.* killing) some fraction of the juveniles that are electrofished during the summer field season.

Not much work has been done on this method yet, but it has promise as a relatively simple and efficient way to estimate run sizes using established and familiar field methods. A big drawback is the need to kill juveniles to get their otoliths. However, a small amount of take of juvenile fish would be expected to have negligible effects on viability, because young-of-the-year fish have very low reproductive value, i.e., most of them are going to die before they reach reproductive - perhaps only 0.1% or less will reproduce - so that sampling them will have negligible effects on viability, especially if the sampling is done before the density-regulation that appears to occur during each summer low-flow season. The key unknown at this point is how many fish would have to be sampled to get a reasonable estimate of the number of anadromous mothers, and whether the sampling does in fact pose a negligible increase in risk.

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 objectives and goals. Adaptive management is predicated on the recognition that natural resources systems are naturally variable, and that knowledge of natural resource systems is often uncertain. Further, the response of natural resources systems to restoration and management actions is complex, and frequently difficult to predict with precision. Hence the need to adapt resource management policies, practices and decisions to changing circumstances or a better understanding of natural resource systems and their responses.

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 impacts-specific concerns. However, six such elements associated with adaptive management have been identified (Panel on Adaptive Management for Resource Stewardship 2004):

1st Element – Recovery Action Objectives are Regularly Revisited and Revised – Key recovery action objectives (and related questions) should be regularly reviewed in an iterative process to help stakeholders maintain a focus on objectives and appropriate revisions to them. The recovery goals, objectives, and criteria in Chapter 5 should provide a basic framework, and the recovery actions identified for each BPG should be a starting point for the adjustment of recovery action objectives. The mandatory five-year review process can serve as a means of conveying any needed modification to the overall recovery goals, as well as individual recovery actions.

2nd Element – Model(s) of the System Being Managed – Four types of models have been have been identified in the use of adaptive management program to test hypothesis regarding the effectiveness of recovery actions (Thomas, *et al.*, 2001):

Conceptual Model:	Synthesis of current scientific understanding, field observation and professional judgment concerning the species, or ecological system
Diagrammatic model:	Explicitly indicates interrelationships between structural components, environmental attributes and ecological processes
Mathematical model:	Quantifies relationships by applying coefficients of change, formulae of correlation/causation
Computational Model:	Aids in exploring or solving the mathematical relationships by analyzing the formulae on computers.

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 not based on data specific to the southern California Recovery Planning Area. Additional quantifiable data is necessary to refine the viability population and DPS models which 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 action in individual populations or BPGs.

3rd Element – A Range of Management Choices – Even when a recovery action objective is agreed upon, uncertainties about the ability of possible recovery or management actions to achieve that objective are common. The range of possible recovery or management choices should be considered at the outset. This evaluation addresses the likelihood of achieving management objectives and the extent to which each alternative will generate new information or foreclose future choices. A range of recovery actions and management measures should be considered, either through a planning process or the environmental review process prior to permitting the individual recovery action.

4th Element – Monitoring and Evaluation of Outcomes – Gathering and evaluation of data allow for the testing of alternative hypotheses, and are central to improving knowledge of ecological and other systems. Monitoring should focus on significant and detectable indicators of progress toward meeting recovery objectives. Monitoring programs and results should be designed to improve understanding of environmental systems and models, to evaluate the outcomes of recovery actions, and to provide a basis for better decision making. It is critical that "thresholds" for interpreting the monitoring results are identified during the planning of a monitoring program. This element of adaptive management will require a design based upon scientific knowledge and principles. Practical questions to be addressed include what indicators to monitor, and when and where to monitor. Guidance on a number of these issues is provided in the sections above regarding research and monitoring.

5th Element – A Mechanism for Incorporating Learning Into Future Decisions – This element recognizes the need for means to disseminate information to a wide variety of stake-holders, and a decision process for adjusting various management measures in view of the monitoring findings. Periodic evaluations of the proposed recovery action, the monitoring data and other related information, and decision-making should be an iterative process in which management objectives are regularly revisited and revised accordingly. A 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. However, despite the existence of varying viewpoints, NMFS has an obligation to fulfill its mission and statutory responsibilities.

13.5.2 Conservation Hatcheries

One adaptive management strategy involves the use of conservation hatcheries to preserve eminently threatened populations, or to accelerate restoration of steelhead runs by temporarily supplementing natural production. While a conservation hatchery program[6] can complement the overall recovery effort, the role of such a program cannot be reasonably expected to substitute for the extensive restoration of habitat function, value, and connectivity that is required to abate threats to southern California steelhead. Rather, the role of the conservation hatchery would be to preserve the genetic and phenotypic characteristics that promote life-history variability through captive broodstock, supplementation, and gene-bank programs, and to reduce the short-term or immediate risk of extinction. An important consideration within the overall planning for recovery of endangered steelhead involves knowing when to start a conservation hatchery.

13.5.2.1 Considerations for Starting a Conservation Hatchery

The appropriate use for a conservation hatchery should be guided by several considerations: (1) the biological significance of the subject 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.

1. The biological significance of a population is expressed in the innate genetic and phenotypic characteristics, and other novel biological and ecological attributes, particularly those attributes that are not observed in other conspecific populations. With regard to the endangered Southern California steelhead DPS, the characterization of the historical steelhead population developed by the TRT provides evidence that certain watershed-specific populations possess a high likelihood of producing steelhead with genetic and phenotypic characteristics that favor survival in a spatially and temporally variable environment. Because many of the inland populations (e.g., Santa Maria River, Santa Ynez River, Ventura River, Santa Clara River, San Gabriel River, San Luis Rey River) extend over a broad geographic and physicochemical diverse area, these populations are able to withstand environmental stochasticity and possess ecologically significant attributes not found in most other populations.

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

[6] A conservation hatchery is a "facility" that propagates indigenous steelhead taken from the wild that will be returned to reproduce naturally in their native habitats.

individual populations, but may require further research specifically for populations of southern California steelhead.

3. Whether a population is likely to be viable is another key considering in determining the proper timing of a conservation hatchery. In particular, information about population size, population growth rate, spatial structure, and diversity provide an indication of the sort of extinction risk a species faces. Generally, small populations have a higher risk of extinction than larger populations. With regard to the endangered Southern California Steelhead DPS, evidence indicates the populations are at high risk of extinction and are not currently viable. A numerical population viability threshold of 4,150 steelhead (adults) per year has been estimated, yet the available information suggests the actual number of adults in the population is considerably lower than the viability threshold.

4. 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.

13.5.3 Numerical Thresholds

Thresholds of numerical abundance have been proposed as a means for preventing population and genetic extinction (including the potential loss of genetic diversity due to small population size) and, in turn, for knowing when a conservation hatchery should be started. Although a detailed review of the methods for arriving at an appropriate numerical threshold is beyond the scope of this section, the numerical thresholds are generally based on estimates for maintaining N_e, and the computation takes into account the average effective breeders per year and the generation time or average age of spawners. It is also suggested that consideration be given to the number of individuals that would be removed from the population for propagation in the conservation hatchery (i.e., the numerical effects of removing fish from the wild for propagation). Generally, populations with a number of breeders that exceeds the estimated N_e are suggested to be able to maintain equilibrium levels of genetic diversity through the minimization of losses due to genetic drift. By contrast, a population with a number of breeders that is less than N_e suggests that artificial propagation be considered.

13.5.4 Assessing Cost Effectiveness of Recovery Actions

To recover an endangered population of steelhead trout, one must somehow allocate scarce dollars (or other resources) to this array of habitats and stressors. This requires a common currency by which to compare various options, both prospectively and retrospectively.

The most pressing recovery need is to improve the population growth rate. Mean growth rate is the average number of adults per adult in the previous generation. A useful common currency for comparing recovery actions is their cost-efficiency with respect to growth rate. This is defined as the improvement in growth rate per unit of recovery expenditure, and can be parsed into three separate components (Baxter *et al*., 2006): 1) the cost of a recovery action—for example, the cost of

restoring 2 km of juvenile creek habitat; 2) some measure of the quantity or quality of habitat - typically this improvement should be measurable as some form of change in the physical structure or dynamics of habitat, such as a change in mean August streamflow or as additional kilometers of stream accessible to migrating fish; and 3) a vital rate—survival, fecundity—of a particular steelhead life stage. Thus, to get an idea of the effectiveness of a recovery action, one must monitor the vital rates of the steelhead life stages affected by the recovery action. The *responsiveness* of population growth rate to a given improvement in survival or fecundity is also called sensitivity in the literature, and is important because responsiveness can differ strikingly across different life stages, so that a similar improvement in survival of two different life stages can have rather different effects on population growth. Estimating the responsiveness requires long-term tracking of annual run size.

13.5.4.1 Marginal Cost

The marginal cost is the unit cost of a achieving some desired change in habitat condition, or some other desired trait of the environment or management regime. In general this component is already being actively estimated in much of California, under the labels of effectiveness monitoring and validation monitoring. However, to adapt the results of this monitoring to estimating the cost efficiency in terms of the fish, the change-in-condition terms (quality or quantity of habitat) must translate—that is they must have comparable interpretation in the effectiveness monitoring and in the experiments (described below) that would be used to estimate effectiveness of the action.

13.5.4.2 Effectiveness

Effectiveness is the response of a vital rate (usually survival) to a change in habitat condition, removal of a stressor, or some other physical change produced by a recovery action. Generally, effectiveness would need to be estimated by experiments—either by controlled, stand-alone field experiments; or by incorporating habitat-specific monitoring into a general monitoring program, in such a way that one can estimate the difference in vital rates in and out of a restored area or a management regime. An example of the latter can be found in Wilson (2003) who, in the context of a sensitivity analysis, compared the effectiveness of smolt migration through Columbia River dams, vs. artificially transporting the smolts using trucks (See also Kareiva *et al*., 2000).

In practice, experiments are expensive and one cannot conduct them for all improvements of habitat that might be proposed. It is sensible to set priorities. This is straightforward, once one has enough monitoring data to estimate the responsiveness of the population to each life-history stage. For example, if it was found that population growth responds more strongly to an improvement in the survival of smolts (downstream migrants), compared to survival of fry (newly hatched juveniles), then you might decide to prioritize experiments that test ways to improve the survival of smolts.

13.5.4.3 Responsiveness

Responsiveness (change in mean growth rate as a function of a change in survival or fecundity) is generally approximated as the partial derivative known as *sensitivity* in the scientific literature. There is a large literature on estimating sensitivity, and the related quantity known as elasticity; a useful entry to the literature is de Kroon *et al*. (2000). Some key points are:

- The method requires estimates for the mean vital rates for each life stage (survival, fecundity, smolting probability, and spawning probability), and these must be assembled into a matrix model that describes the life cycle of the fish. Estimating the vital rates requires monitoring data—for at least a sufficient number of years to obtain credible estimates of mean rates.

- A vital rate may have high responsiveness but little room for improvement—for example growth rate may be responsive to adult survival, but adult survival might already be, say, 90% and thus offer little room for improvement (but great scope for deterioration, with large effects on growth). In such cases recovery actions would have to focus on life stages of lower responsiveness but greater scope for improvement.

- The substitution of the partial derivative for the difference operator ($X_{before} - X_{after}$) involves a linear approximation of a non-linear response. In practice this appears to be a reasonable assumption when comparing individual actions (each impacting a single life stage) (de Kroon *et al.*, 2000). However, a more sophisticated goal is to assemble an array of actions (impacting an array of life stages) in order to achieve a particular level of improved population growth. In such cases the non-linearities may become more pronounced (Hodgson and Townley, 2004), and indeed one could view these non-linearities as synergies (non-additive effects) that can be optimized in some sense. In this case, robust control theory can be applied to the problem; an entry to the literature is Hodgson and Townley (2004).

- The most common methods ignore the variation of, and density dependence in, the vital rates. They are thus approximations of the true sensitivities.

13.5.4.4 Omissions

The focus so far has been on improving the mean growth rate of a population. This should reduce extinction risk by increasing both the population's size and its resiliency. A third way to reduce risk, not yet addressed, is to reduce the variation that the growth rate exhibits over time. In principle the concepts of responsiveness, effectiveness and cost efficiency can be applied to variation in growth rates as well as to its long-term mean. In practice, the quantitative tools have not been developed yet (but see Fujiwara, 2007).

A qualitative solution is to implement recovery actions that promote life-history diversity and habitat diversity. The risk of focusing exclusively on growth-efficiency is that certain habitat/life-stage combinations may promote sustained population growth in most years but also be vulnerable to occasional catastrophic failures. An example of such a combination is the use of lagoon habitat by young-of-year steelhead. Evidence suggests that lagoon-reared steelhead usually contribute disproportionately to adult runs, compared to stream-reared steelhead (Bond, 2006), but observation also suggests that occasionally a year class experiences complete mortality due to lagoon breaching. A complete focus on growth-efficiency would probably identify the importance of lagoon-reared fish but not their vulnerability, and thus not the stabilizing influence of stream reared fish.

13.5.4.5 Summary

A common currency for comparing recovery activities is a salmon population's growth-efficiency under various recovery scenarios. Growth efficiency is the change in population growth rate per unit expenditure for a specific recovery activity. The net growth efficiency of a combination of activities can also be estimated, but requires advanced techniques. Using growth efficiency for decision-making entails four key concepts: Sensitivity of population growth to a given vital rate of the fish; the scope for improvement in a vital rate; the efficacy of a given environmental change in improving the vital rate; and finally, the implementation cost of changing the environment. Two other key ingredients are 1) population monitoring data sufficient to estimate the sensitivities and experiments to determine the efficacy of recovery actions. The overall approach described here focuses on increasing the population growth rate, but another worthy goal is to decrease the variation in the growth rate over time. Scientific tools for achieving efficiency in this second-order goal are only partially developed, but qualitative approaches—in which one secures alternative life-history pathways—will frequently be sufficient.

14. Implementation by NMFS

"You are capable of more than you know. Choose a goal that seems right for you and strive to be the best, however hard the path. Aim high. Behave honorably. Prepare to be alone at times, and to endure failure. Persist! The world needs all you can give."

Edward O. Wilson

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 NMMS' missions can be accomplished with due consideration to the needs of listed salmon and steelhead. If NMFS is to promote species and ecosystem conservation (and meet its own obligations under section 7(a)(1) of the ESA), then means of incorporating recovery goals and actions must be incorporated into all of the programs and actions we administer and implement. This includes, for example, listing reviews and critical habitat designations under ESA section 4, ESA consultations under section 7, and permit actions under ESA section 10.

Implementation of the recovery plan by NMFS will take many forms and is generally and specifically described in the NMFS PRD Strategic Plan 2006 (Appendix E). The Recovery Planning Guidance (NMFS 2006) also outlines how NMFS shall cooperate with other agencies regarding plan implementation. These documents, in addition to the ESA, shall be used by NMFS to set the framework and environment for plan implementation. The PRD Strategic Plan asserts that species conservation (in implementing recovery plans) by NMFS will be more strategic and proactive, rather than reactive. To maximize existing resources with workload issues and limited budgets, the PRD Strategic Plan champions organizational changes and shifts in workload priorities to focus efforts towards "those activities or areas that have biologically significant beneficial or adverse impacts on species and ecosystem recovery" (NMFS 2006). 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:

1. Formalizing recovery planning goals on a program-wide basis to prioritize work load allocation and decision-making (to include developing the mechanisms to make implementation, *e.g.*, restoration, possible).
2. Conducting an aggressive outreach and education program.

3. Facilitating a consistent framework for research, monitoring, and adaptive management that can directly inform recovery objectives and goals.

4. Establishing an implementation tracking system that is adaptive and pertinent to annual reporting for the Government Performance and Results Act, Bi-Annual Recovery Reports to Congress and 5-Year Reviews of each species listing status.

14.1.1 Work with Constituents

Successful implementation of recovery plans will require the efforts and resources of many entities, from federal agencies to the individual contributions of members of the public. NMFS commits to working cooperatively with other individuals and agencies on implementation of recovery actions and to encourage other federal agencies to implement the actions for which they have responsibility or authority. The benefits of a successful plan to the species and the currently regulated communities are immense, but the costs can be counted in time, money, and changed behaviors. NMFS is committed to using recovery plans as the guiding mechanism for its daily endeavors and can directly implement some of the actions called for in the plans. However, our primary role in plan implementation will be to champion the recovery strategy and provide the needed technical information and expertise to other entities implementing the plan or contemplating actions that may impact the species' chances of recovery.

NMFS is engaged in outreach to various constituencies where we provide technical assistance regarding listed salmon, their habitat needs, and various life-history requirements. Developing partnerships through providing technical assistance will be critical for recovery. Our outreach efforts will need to increase both towards those constituencies with which we already engage and to expanded sets of constituencies including communities, resource groups, and Federal and State legislative representatives. Through this role NMFS shall focus efforts in key areas critical for recovery through the following actions:

- ❑ Work to assure funding and staff for full enforcement of laws, codes, regulations and ordinances across the Southern California steelhead DPS.

- ❑ Develop outreach and educational materials to change attitudes and action of the general public to provide recovery benefits.

14.1.2 Coordination with other NMFS Divisions

Other divisions within NOAA can contribute significantly to recovery. NMFS PRD staff will coordinate closely with the SWFSC, Habitat Conservation Division, and NOAA Restoration Center to assist in the development, review and funding of restoration projects in primary areas.

14.2 ONGOING REGULATORY PRACTICES

The ESA provides NMFS 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).

In the case of listed salmon and steelhead in California, NMFS has already used the listing and designation of critical habitat provisions to protect the current populations of these species. For the past two decades, NMFS has also worked closely with federal agencies and private landowners pursuant to sections 7(a)(2) and 10(a)(1) of the ESA to avoid and minimize additional harm to these species during the course of land and water-use activities. Significant benefits have already accrued to these listed species from changes in land and water-use practices. Unfortunately, in many areas, salmon and steelhead populations continue to decline. The development and implementation of recovery plans has a greater scope and objective than the project-by-project focus of most section 7 and 10 efforts, however. NMFS intends to use this broader perspective to effect more significant and focused beneficial change for salmon and steelhead. In addition, NMFS commits to implement every action within this recovery plan for which it has authority.

The following sections describe the methods NMFS intends to use when implementing various sections of the ESA. These methods are intended to institutionalize the recovery plans in the daily efforts and decision-making at NMFS in the Southwest Region. Of necessity, some of these methods address the urgent issues of staffing and workload that NMFS faces. As a result, our commitment to implementing recovery plans extends to the ways in which we prioritize the many requests for consultations and permits we receive.

14.2.1 ESA Section 4

Section 4 provides the mechanisms to list new species as threatened or endangered, designate critical habitat, develop protective regulations for threatened species, and to develop recovery plans. NMFS intends on using our recovery strategy, recovery criteria and recommended recovery actions to revise the Southern California steelhead DPS critical habitat designation as needed.

14.2.2 ESA Section 5

Section 5 is a program that applies to land acquisition with respect to the National Forest System. Four National Forests (Los Padres, Angeles, Cleveland and San Bernardino) are present within the range of Southern California steelhead. As funds are available, section 5 could be used to acquire important habitat areas for the purpose of protecting habitat features and functions needed to support the expression of diversity and spatial structure in the species.

14.2.3 ESA Section 6

Section 6 describes protocols for consultation and agreements between NMFS and the states for the purpose of conserving threatened or endangered species. California does not currently have a section 6 agreement with NMFS.

As another 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, 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 Southern California steelhead recovery strategy and priorities are included in the considerations of funding for projects. NMFS also intends on using PCSRF reports as a mechanism to highlight those areas and actions where PCSRF funds have been used to implement needed recovery actions that might not otherwise occur in the absence of PCSRF funds.

14.2.4 ESA Section 7

14.2.4.1 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 endangered species a high priority. To date, most Federal agencies have not complied with the section 7(a)(1) requirement to develop conservation programs for Southern California steelhead. To prompt Federal agencies to develop conservation programs, 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 threat abatement, for all actions that incidentally take steelhead or affect their habitat.
- ❑ Encourage Federal partners to include recovery actions in project proposals.

14.2.4.2 Section 7(a) (2)

The purpose of section 7(a)(2) is to "insure that any action authorized, funded, or carried out by [a Federal agency] is not likely to jeopardize the continued existence of any [listed species] or result in the destruction or adverse modification of [a listed species' critical habitat]." Federal agencies request interagency consultation with NMFS when they determine an action may affect a listed species or its critical habitat. NMFS then conducts an analysis of potential effects of the action. In the process of consultation, NMFS currently expends considerable effort to assist agencies in avoiding and minimizing the potential effects of proposed actions, and to ensure agency actions do not jeopardize a species or destroy or degrade habitat. Whether the action has a negative effect on the likelihood of the species recovering is considered as part of the analysis; the action may not preclude recovery, but the action is not required to contribute to recovering the species, although it may contribute to recovery. As a result, these consultations have helped avoid and minimize direct take but have done little to contribute to recovery of Southern California steelhead DPS.

Because section 7(a)(2) applies only to Federal actions, its applications are limited only to those areas and actions with federal ownership, oversight, or funding. In the Southern California steelhead DPS land ownership varies across the watersheds from areas with significant levels of public ownership to areas almost entirely privately owned. Most of the land use practices on private ownership do not trigger interagency consultation.

Currently, NMFS expends most of its staff time and resources on conducting section 7 consultations. Implementation of the Recovery Plan will require improvements to the process and application of section 7(a)(2) consultation requirements across the 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 Southern California 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.
- ❑ Focus staff priorities towards section 7 compliance in watersheds designated as a primary focus for recovery and direct efforts to recovery implementation.
- ❑ 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.

- Apply the VSP framework and recovery priorities to evaluate population and area importance in jeopardy and adverse modification analysis.

Within this framework NMFS will utilize its authorities to encourage:

- The Federal Emergency Management Agency (FEMA) to fund upgrades for flood-damaged facilities to meet the requirements of the ESA and facilitate recovery.
- The Environmental Protection Agency (EPA) to prioritize actions on pesticides known to be toxic to fish and/or are likely to be found in fish habitat; and to take protective actions, such as restrictions on pesticide use near water.
- Development of section 7 Conservation Recommendations to help prioritize Federal funding towards recovery actions (NFMS, USFWS, NRCS, EPA, *etc.*) during formal consultations.
- All Federal agencies who designate a non-Federal representative to conduct informal consultation or prepare a biological assessment to ensure the associated documentation comports to 50 CFR 402.14(c) prior to initiating consultations with NMFS. Compliance with these requirements is expected to increase consultation effectiveness and timeliness.
- All Federal agencies, or their designated representatives, to field review projects and actions upon project completion to determine whether or not the projects were implemented as planned and approved. Encourage all Federal agencies, or their designated representatives to report the initial findings of field review to NMFS.
- Federal agencies to coordinate and develop programmatic incidental take authorization for activities that contribute to the recovery of Southern California steelhead, to streamline their permitting processes.

14.2.5 ESA Section 9

Section 9 prohibits any person from harming members of listed species including direct forms of harm such as killing an individual, or indirect forms such as destruction of habitat where individuals rear or spawn. The recovery plan will assist NMFS' Enforcement personnel by targeting focus watersheds essential for species recovery. NMFS PRD staff will work closely with NMFS Enforcement regarding the identification of threats and other activities believed to place steelhead at high risk of take. Actions will include the following:

- NMFS will conduct outreach and will provide Enforcement a summary of the recovery priorities and threats.
- NMFS will prioritize those actions and areas deemed of greatest threat or importance for focused efforts to halt illegal take of listed species.
- NMFS will develop a plan to outline responsibilities and priorities between PRD and Enforcement to ensure activities by NMFS staff, when supporting Enforcement, are focused on the highest recovery priorities.
- When take has occurred in a primary focus area, NMFS PRD will work with NMFS Enforcement, to the extent feasible, with the development of a take statement.

14.2.6 ESA Section 10

Section 10(a)(1)(A) provides permits for the authorization of take of listed species for scientific research purposes, or to enhance the propagation or survival of listed species. Typically NMFS has authorized conservation hatcheries and research activities under section 10(a)(1)(A). Section 10(a)(1)(B) provides permits for otherwise lawful activities that incidentally take listed species. Habitat conservation plans minimizing and mitigating the incidental take of listed species from non-federal activities are prepared under section 10(a)(1)(B). Currently, both processes take a long time to implement and recovery plans have not been available to guide priorities for permit issuance. To improve the section 10 authorization process, NMFS will utilize its authorities in the following ways:

14.2.6.1 Section 10(a) (1) (A) Research Permits

- ❑ Prioritize permit applications that address identified research and monitoring needs in the recovery plan. Develop streamlined approaches to permitting similar types of research or research programs in primary focus areas.
- ❑ Evaluate all proposed activities against the identified threats, recovery strategy, and recovery actions identified in the plan.
- ❑ Develop and maintain databases to track the amount of take authorized and the effectiveness of conservation and mitigation measures.

14.2.6.2 Section 10(a) (1) (B) Habitat Conservation Plans

- ❑ Place the highest priority on cooperation and assistance to landowners proposing activities or programs designed to achieve recovery objectives.
- ❑ 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.
- ❑ Standardize monitoring methods in HCPs to identified monitoring and effectiveness needs identified by the TRT and Recovery Plan. Consistent data collection techniques and the ability to compare similar data sets over space and time will set the framework for tracking recovery progress and conducting 5-year status reviews.

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APPENDIX A

Glossary And Abbreviations

Anadromous Fraction. The proportion of an *O. mykiss* population that exhibit the anadromous life history, as opposed to the freshwater-resident life history.

Life-History Crossover. Anadromous *O. mykiss* among the progeny of freshwater-resident *O. mykiss*, and/or vice versa.

Life-History Polymorphism. Co-occurrence of the anadromous and resident forms.

Phenotypic Plasticity. The ability of an individual fish to adopt either the anadromous or freshwater-resident life history, depending on environmental cues or influences.

Steelhead Nursery Habitat. Freshwater habitat that disproportionately generates recruits to the anadromous adult component of the species.

Rainbow Trout Nursery Habitat. Freshwater habitat that disproportionately generates recruits to the freshwater-resident adult component of the species.

Estuary. The aquatic interface between a freshwater stream system and the ocean.

Seasonal Lagoon. An estuary that becomes separated from the ocean by a sandbar barrier for part of the year.

Ephemeral Streams. Streams that flow briefly after rainstorms.

Intermittent Streams. Streams that flow for some, but not all, of the year in question.

Sub-Perennial Streams. Streams that flowed all of the year in question; but not necessarily all year, every year.

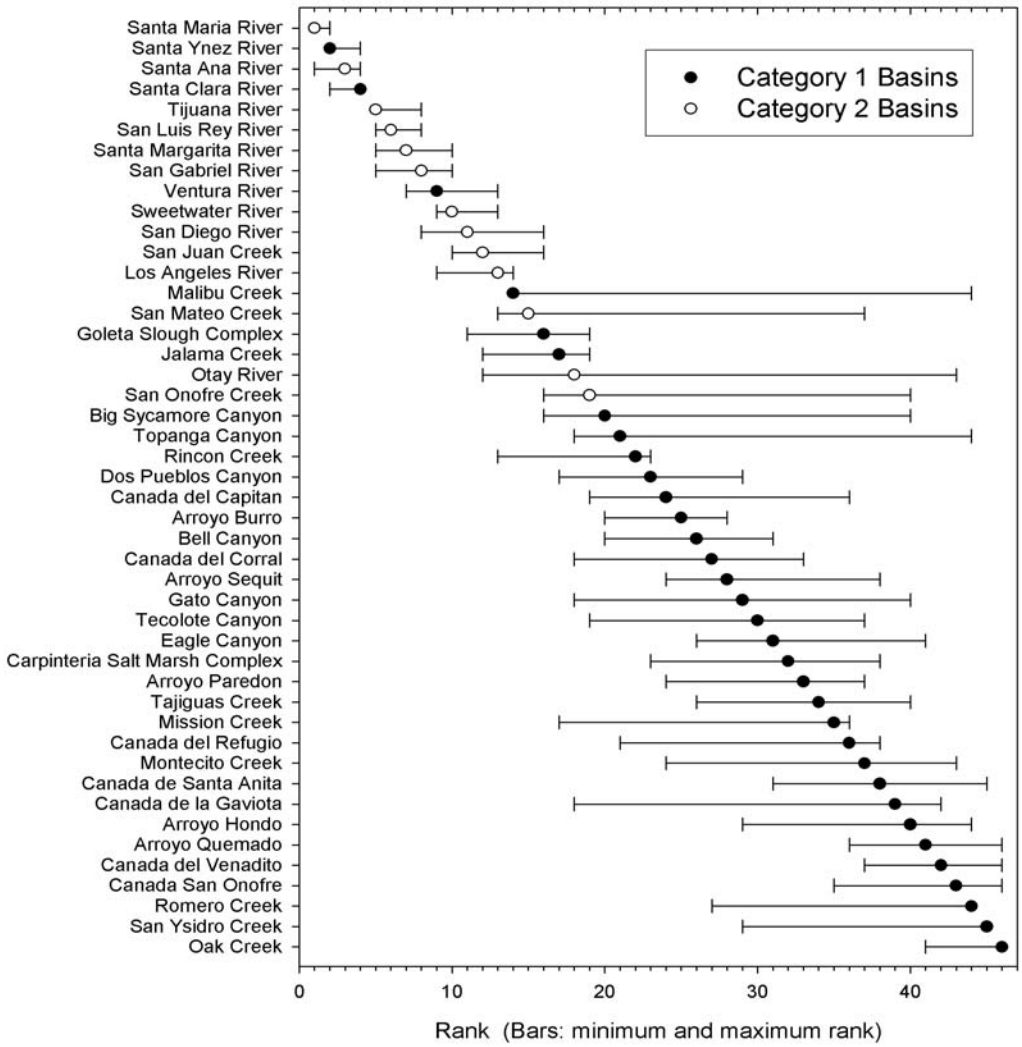
Perennial Streams. Streams that flow all year, every year.

Perennial Reaches. Individual reaches that flow all of the year in question, perhaps embedded within an intermittent stream.

AFRP	Anadromous Fish Restoration Program
CAMP	Comprehensive Assessment and Monitoring Program
CDFG	California Department of Fish and Game
CESA	California Endangered Species Act
CMARP	Comprehensive Monitoring Assessment and Research Program
cm	centimeters
cm/sec	centimeters per second
CWT	Coded Wire Tag
DPS	Distinct Population Segment
DWR	Department of Water Resources
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Unit
FL	fork length
ft/sec	feet per second
HCP	Habitat Conservation Plan
m	meters
mi^2	square miles
m/sec	millimeters per second
mm	millimeters
NMFS	National Marine Fisheries Service
NOAA	National Oceanic and Atmospheric Administration
PCSRF	Pacific Coastal Salmon Recovery Fund
PVA	Population Viability Analyses
RWQC	Regional Water Quality Control
BOR	Bureau of Reclamation
RM	River Mile
RST	Rotary Screw Trap
SWP	State Water Project
TRT	Technical Recovery Team
USFWS	U.S. Fish and Wildlife Service
VSP	Viable Salmonid Population

APPENDIX B

Watershed rankings in the Southern California Steelhead DPS.[1] The ranking is based on the amount of potential habitat as in indicator for potential viability. (See Boughton *et al*. 2006).



[1] *Category 1 Watersheds are Watersheds which experience regular winter flows to the ocean and therefore provide access to freshwater spawning areas. Category 2 Watersheds (*i.e.*, all large Watersheds within the southern portion of the Southern California Steelhead DPS, and the Santa Maria River) experience irregular winter flows to the ocean, even in an unimpaired state. Bars indicate the range of ranks (minimum and maximum) for 48 variant models. (See Boughton* et al*. 2006).*

APPENDIX C

COMPOSITION OF SOUTHERN CALIFORNIA COAST STEELHEAD BPGs

(See Boughton *et al*. 2006)

Biogeographic Group	Member Populations (ordered north to south)
Monte Arido Highlands	Santa Maria River, Santa Ynez River, Ventura River, Santa Clara River.
Conception Coast[1]	Jalama Creek, Cañada de Santa Anita, Cañada de la Gaviota, Cañada San Onofre, Arroyo Hondo, Arroyo Quemado, Tajiguas Creek, Cañada del Refugio, Cañada del Venadito, Cañada del Corral, Cañada del Capitan, Gato Canyon, Dos Pueblos Canyon, Eagle Canyon, Tecolote Canyon, Bell Canyon, Goleta Slough Complex, Arroyo Burro, Mission Creek, Montecito Creek, Oak Creek, San Ysidro Creek, Romero Creek, Arroyo Paredon, Carpinteria Salt Marsh Complex, Carpinteria Creek, Rincon Creek.
Santa Monica Mtns[1]	Big Sycamore Canyon, Arroyo Sequit, Malibu Creek, Topanga Canyon.
Mojave Rim	Los Angeles River, San Gabriel River, Santa Ana River (multiple subpopulations).
Santa Catalina Gulf Coast	San Juan Creek, San Mateo Creek, San Onofre Creek, Santa Margarita River, San Luis Rey River, San Diego River, Sweetwater River, Otay River, Tijuana River.

[1] *Population delineation 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

SOUTHERN CALIFORNIA STEELHEAD RECOVERY PLANNING AREA THREATS ASSESSMENT (CAP WORKBOOK) METHODOLOGY

Introduction

The Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service (NMFS) contracted with Hunt & Associates Biological Consulting Services to provide technical support in developing Recovery Plans for *Oncorhynchus mykiss* populations in the Southern California Coast Steelhead Recovery Planning Area. Hunt & Associates was tasked with reviewing existing information on *O. mykiss* habitat conditions, assessing the magnitude and extent of threats to *O. mykiss* and their habitats, and developing recovery actions across the Southern California Coast Recover Planning Area. This document summarizes the methodology used to assess *O. mykiss* threats and sources of threats in Southern California coastal watersheds from the Santa Maria watershed of Santa Barbara County southward to the Tijuana River watershed in San Diego County. Specifically, this document details the use of modified Conservation Action Planning Workbooks to assess watershed and life-stage specific threats and threat sources for Southern California Coast *O. mykiss*. CAP workbooks have been developed previously for salmonid threat assessment and recovery planning for southern Oregon and northern California coast coho salmon as well as south-central and southern California steelhead. However, previous *O. mykiss* threat assessment workbooks, described in Kier Associates and National Marine Fisheries Service (2008), were not inclusive of all watersheds within the Southern California Coast Recovery Planning Area or all available environmental data and information. The CAP workbook analysis results presented in this recovery plan, therefore, builds on information in these earlier versions.

Methods

The Conservation Action Planning (CAP) Workbook is a database tool developed by The Nature Conservancy to identify conservation targets, assess existing habitat conditions, and identify management issues for target populations. CAP is an Microsoft Excel-based tool that facilitates the assessment of aquatic habitat quality and human-caused threats to that habitat. Once data are entered, the CAP workbook then links the observed aquatic habitat conditions to watershed conditions, provides a prioritized list of threats, and provides a summary of overall watershed health. The CAP Workbooks can be used to organize and evaluate large amounts of information on current *O. mykiss* habitat conditions and threats in selected watersheds. The CAP Workbook methodology provides a number of useful features in assessing the magnitude and extent of threats to *O. mykiss* and their habitats in that it:

- Incorporates both quantitative and qualitative (*e.g.*, professional judgment) measures of existing habitat conditions;
- Is an objective, consistent tool for tracking changes in the status of each conservation target (i.e., *O. mykiss* life-history stage) over time and between watersheds;
- Provides an overall assessment of a watershed's "health" or viability and objective comparisons to other watersheds;

- Focuses recovery actions by identifying past, current, and potential threats to *O. mykiss* and their habitats;
- Becomes a central repository for documenting and updating knowledge and assumptions about existing conditions; and
- Creates a foundation upon which recovery actions can be tracked and up-dated, based on changing current conditions.

Twenty-two coastal watersheds, encompassing 46 drainages were identified as supporting historical and extant *O. mykiss* populations within the SCS Recovery Area by Boughton *et al.* (2006), and were selected for threats assessment analysis. A separate CAP Workbook was created for each of the 46 component drainages (Table D-1). Information on existing *O. mykiss* habitat conditions in each watershed was gathered from a broad range of published and un-published materials, including, peer-reviewed scientific publications, technical reports, federal, state, and local planning documents, EIS/EIRs, management plans, passage barrier assessments, habitat evaluations, and field surveys, as well as information provided by NOAA-NMFS staff, and stakeholders and other interested parties at a series of public workshops held in 2007. These sources are listed in the bibliography at the end of this document.

The CAP Workbook process uses available information in an explicit, consistent, and transparent way, to assess current habitat conditions. The CAP Workbook allows the user to input quantitative as well as qualitative (including best professional judgment) information in order to determine what existing conditions are and what healthy targets should look like. The Workbook is iterative and should be updated as additional information becomes available.

Conservation Targets: Specific "conservation targets" for analysis within a CAP workbook must be identified by the user. The conservation targets in this case were *O. mykiss* life-history stages: egg, fry, smolt, and adult. A more general conservation target, "Multiple Life Stages", was also established to allow landscape-scale land use and habitat assessment, based on information derived from GIS-based analysis of entire watersheds.

Key Ecological Attributes (KEAs): Assessing the "viability" or "health" of a particular conservation target (i.e., life-history stage) required identifying "Key Ecological Attributes" (KEA) for each target. Specific KEAs are aspects of the conservation target's biology or ecology such that if missing or severely degraded, would result in loss of that target over time. KEAs, such as substrate quality, non-native species, food availability, water quality, *etc.*, were identified for each target and measurable indicators, such as turbidity, water temperature, aquatic invertebrate species richness, presence or absence of non-native predators, miles of road/square mile of watershed, *etc.*, were identified in order to characterize existing conditions in the component watersheds. All KEAs were grouped into three categories:

- *Size*: target abundance (*e.g.*, number of adult *O. mykiss*);
- *Condition*: a measure of the biological composition, structure, and biotic interactions that characterize the target's occurrence (i.e., generally a local measure of habitat quality or composition), and;

Table D-1. Southern California Steelhead Recovery Planning Area Component Biogeographic Population Groups, Watersheds, and Corresponding CAP Workbooks.

BPG	Watershed	CAP Workbook
Monte Arido Highlands	Santa Maria River	Mainstem Santa Maria River
		Cuyama River
		Sisquoc River
	Santa Ynez River	Mainstem Santa Ynez River (lower, middle, and upper)
	Ventura River	Mainstem Ventura River
		Coyote Creek
		Mainstem Matilija Creek
		North Fork Matilija Creek
		San Antonio Creek
	Santa Clara River	Mainstem Santa Clara River
		Santa Paula Creek
		Sespe Creek
		Piru Creek
Conception Coast	Jalama Creek	Jalama Creek
	Canada de Santa Anita	Canada de Santa Anita
	Gaviota Creek	Gaviota Creek
	Arroyo Hondo Creek	Arroyo Hondo Creek
	Tecolote Creek	Tecolote Creek
	Goleta Slough	San Jose, Atascadero, San Pedro & Maria Ygnacio creeks
	Mission Creek	Mission Creek
	Montecito Creek	Montecito Creek
	Carpinteria Creek	Carpinteria Creek
	Rincon Creek	Rincon Creek
Santa Monica Mountains	Big Sycamore Canyon Creek	Big Sycamore Canyon Creek
	Arroyo Sequit	Arroyo Sequit
	Malibu Creek	Malibu Creek
	Las Flores Canyon Creek	Las Flores Canyon Creek
	Topanga Canyon Creek	Topanga Canyon Creek
Mojave Rim	Los Angeles River	Mainstem Los Angeles River
		Arroyo Seco
	San Gabriel River	Mainstem San Gabriel River
		East Fork San Gabriel River
		West Fork San Gabriel River
	Santa Ana River	Mainstem Santa Ana River
		Lytle Creek
		Mill Creek
Santa Catalina Gulf Coast	San Juan River	San Juan River/Trabuco Creek
	San Mateo Creek	San Mateo Creek
	San Onofre Creek	San Onofre Creek
	Santa Margarita River	Santa Margarita River
	San Luis Rey River	San Luis Rey River
	San Dieguito River	San Dieguito River
	San Diego River	San Diego River
	Sweetwater River	Sweetwater River
	Otay River	Otay River
	Tijuana River	Tijuana River

- *Landscape Context*: an assessment of the target's environment (*i.e.*, landscape-scale processes, such as connectivity, accessibility of spawning habitat; hydrology).

Current Indicators: The range of variation found for each indicator was then subdivided into four somewhat subjective, but discrete, categories: "Poor", "Fair", "Good", or "Very Good". The current condition of a specific indicator, taken from a field measurement, literature source, or professional judgment, is assigned to one of these four discrete rating categories. A description of indicators used in the CAP steelhead analyses and the rationale for these indicators is available in Kier Associates and National Marine Fisheries Service (2008). Functionally; however, we assumed that there are essentially two states for an indicator as it relates to the target: 1) "poor-fair", in which the indicator exceeds or minimally meets the requirements for species survival and the population is in danger of extirpation, and 2) "good-very good", where habitat conditions are favorable for species persistence.

The CAP Workbook can use indicators at a local, regional, and landscape-scale. For example, land use indicators, such as density of roads per square mile of watershed, has been widely employed as a landscape-scale metric of watershed "health" for salmonids throughout the western United States (see Kier Associates and NMFS, 2008). These landscape-scale metrics were used in this threat assessment to overcome logistical and analytical problems inherent in local-scale metrics of *O. mykiss* habitat quality (*e.g.*, water temperature), that exhibit extreme spatial and temporal variation, which can lead to misinterpretations.

The goal of establishing measurable indicators in a number of instances was not possible with the current knowledge of existing habitat conditions in the component watersheds. For example, turbidity is known to be an important habitat indicator for *O. mykiss*. For the *O. mykiss* fry life stage, turbidity was defined as the "number of days turbidity exceeded 25 NTUs". Currently, there is little or no systematic and widespread collection of turbidity data in most of the subject watersheds drainages to permit a quantative assessment of this indicator. In these instances, subjective information, such as observations of mass wasting of slopes, descriptions of point and non-point sediment inputs, *etc.*, were used to qualitatively assess a current condition and rating for this indicator. Because the CAP Workbook analysis is iterative, results can be improved as better quantitative information becomes available.

Stresses and Sources of Stress (Threats): An important step in the CAP Workbook assessment, and the purpose of these analyses, is identification of a series of stresses to each *O. mykiss* life-history stage. These stresses are basically altered KEAs and directly affect the life-stage, *e.g.*, degraded hydrologic function, increased turbidity, presence of non-native predators, increased substrate embeddedness). Because of the lack of field derived information on specific habitat requirements (i.e., tolerances) and specific habitat conditions, the GIS-based surrogate variables used for the "Multiple Life Stages" conservation target actually are sources of stress, not direct stressors on *O. mykiss* life stages (*e.g.*, increased road density (a source of stress) contributes indirectly to increased turbidity (a direct stressor). The severity (very high, high, medium, or low) and geographic scope (very high, high, medium, and low) of each stress was determined through a review of existing information. The CAP Workbook then assigns an overall stress rank (very high, high, medium, or low) to that stress.

The CAP Workbook automatically inputs the overall rank of each stress into a table that relates the stress to a series of anthropogenic sources of stress (also called Threats) that have been identified by the user as relevant to that watershed (*e.g.*, roads, grazing practices, logging, recreational facilities, agricultural conversion of watershed lands, dams, groundwater extraction, in-channel mining, *etc.*). Each threat is ranked on the basis of its relative "contribution" (very high, high, medium, or low) and "irreversibility" (very high, high, medium, or low) to each stress (*e.g.*, increased turbidity). The CAP Workbook then ranks the threat (source of stress) as "Very High', "High", "Medium", or "Low" and inputs that rank into the next step of the assessment. This process is repeated for each conservation target (egg, fry, juvenile, smolt, and adult), as well as the "Multiple Life Stages" conservation target.

Summary of Threats: The CAP Workbook ranks the threat sources for each conservation target (*i.e.,* life-history stage) from the previous analysis into a "Summary of Threats" table that lists all the threat sources for all life-history stages and assigns a composite "Overall Threat Rank" to each threat source (*e.g.,* dams and surface water diversions), as well as an overall threat rank to that watershed for all threat sources combined. The Workbook derives a second table ("Stress Matrix") that shows the rank of each stress on each life-history stage. The final step in the steelhead CAP assessment is the derivation of a third table entitled, "Overall Viability Summary", that ranks the viability of each life-history stage and KEA category (size, condition, and landscape context) by calculating a composite rank of the current habitat indicators from the "Viability" table of the workbook, as well as an overall "Project Biodiversity Health Rank", which is a measure of watershed "health" based on current habitat conditions. The first and third summary tables proved the most useful in analyzing stresses and sources of stress to *O. mykiss* in the Southern California Coast Steelhead Recovery Planning Area.

*Data Gaps. T*he 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. In general, the level of available information on current watersheds conditions relevant to *O. mykiss*, with a few notable exceptions, decreased dramatically south of the Santa Monica Mountains (*e.g.*, the Mojave Rim Biogeographic Population Group watersheds and most of the Orange and San Diego county watersheds). However, an important feature of the CAP Workbook methodology is the ability to update the assessment as information becomes available.

The CAP Workbook analysis of Southern California *O. mykiss* prepared by Hunt & Associates was intended to build on those prepared previously by Kier Associates. Hunt & Associates' workbooks are based on review of a large number and broad range of ground-based *O. mykiss* surveys, habitat and barrier assessments, and other fieldwork, as well as the GIS-based indicators for the "Multiple Life History" target category developed by Kier Associates. Hunt & Associates developed CAP Workbooks for each of the 46 watersheds in the Southern California Coast Steelhead Recovery Planning Area. Kier Associates analyzed 31 of these watersheds, using the GIS-based regional indicators and a small number of point-data measurements (e.g., dissolved oxygen, water temperature, *etc.*). Kier Associates' workbooks are provided in a separate document (Kier Associates and NMFS, 2008).

Table D-2 compares the results of the two documents for watersheds in the Southern California Coast Steelhead Recovery Planning Area. It should be noted that the difference between a "poor" and "fair" habitat rating or a "good" and "very good" rating was often a matter of professional judgment and may not always represent ecologically important differences in habitat quality. Table 1 explains discrepancies between "poor-fair" and "good-very good" categories between the Hunt & Associates and Kier Associates CAP Workbook analyses.

Discrepancies typically could be explained by the type (point-data measurements) and the number of indicators used in the analysis by Kier Associates versus Hunt &Associates. As the number of indicators decreases, the relative weight given to each indicator in the analysis correspondingly increases, and if these indicators are based on point-data measurements, such as water temperature or dissolved oxygen, that exhibit extreme spatial and temporal variation, then different results can be obtained. Aside from these relatively few specific differences, the results of the two assessments closely agree.

Further refinement of individual threat severity and threat sources in specific watersheds was conducted for these threat assessments by using information from NOAA staff familiar with these watersheds to override certain final assessments.

Table D-2. Assessment of Overall Habitat Conditions for Steelhead in Component Watersheds in the Southern California Coast Steelhead Recovery Planning Area Between Two CAP Workbook Analyses*

WATERSHED	Steelhead Habitat Rating		Reasons for Discrepancy**
	Hunt & Associates	Kier Associates	
Santa Maria River			N/A
Santa Ynez River			fewer number of indicators used in the latter analyses
Ventura River			fewer number of indicators used in the latter analyses
Santa Clara River			N/A
Gaviota Creek			fewer number of indicators used in the latter analyses
Arroyo Hondo			Hunt & Associates rates passage barrier at Highway 101 as severe, but being re-designed for fish passage. Override function used to rate this relatively undisturbed watershed as "good"
Tecolote Creek			fewer number of indicators used in the latter analyses
Goleta Slough			fewer number of indicators used in the latter analyses
Mission Creek			fewer number of indicators used in the latter analyses
Montecito Creek			fewer number of indicators used in the latter analyses
Carpinteria Creek			fewer number of indicators used in the latter analyses
Rincon Creek			fewer number of indicators used in the latter analyses
Big Sycamore Creek			fewer number of indicators used in the latter analyses
Arroyo Sequit			fewer number of indicators used in the latter analyses
Malibu Creek			N/A
Las Flores Canyon Creek			N/A

Topanga Canyon Creek			N/A
Los Angeles River			N/A
San Gabriel River			N/A
Santa Ana River			N/A
San Juan/Trabuco Creek			N/A
San Mateo Creek			fewer number of indicators used in the latter analyses
San Onofre Creek			fewer number of indicators used in the latter analyses
Santa Margarita River			fewer number of indicators used in the latter analyses
San Luis Rey River			fewer number of indicators used in the latter analyses
San Dieguito River			fewer number of indicators used in the latter analyses
San Diego River			fewer number of indicators used in the latter analyses
Sweetwater River			fewer number of indicators used in the latter analyses
Otay River			fewer number of indicators used in the latter analyses
Tijuana River			fewer number of indicators used in the latter analyses

** Overall habitat condition rating taken from "Project Biodiversity Health Rank" rating in "Overall Viability Summary" table in Summary section of individual CAP Workbooks (composite rating of habitat conditions for all steelhead life-history stages combined). Watersheds analyzed only by Hunt & Associates are not shown.*

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

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

APPENDIX E

HABITAT RESTORATION COST REFERENCES FOR SALMON RECOVERY PLANNING

NOAA Technical Memorandum NMFS

APRIL 2008

HABITAT RESTORATION COST REFERENCES FOR SALMON RECOVERY PLANNING

Cynthia J. Thomson
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NOAA-TM-NMFS-SWFSC-425

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southwest Fisheries Science Center

The National Oceanic and Atmospheric Administration (NOAA), organized in 1970, has evolved into an agency that establishes national policies and manages and conserves our oceanic, coastal, and atmospheric resources. An organizational element within NOAA, the Office of Fisheries is responsible for fisheries policy and the direction of the National Marine Fisheries Service (NMFS).

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APRIL 2008

HABITAT RESTORATION COST REFERENCES FOR SALMON RECOVERY PLANNING

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Introduction

The Endangered Species (ESA) requires that recovery plans for listed species include "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" (ESA Section 4(f)(1)(B)(iiii)). The purpose of this report is to facilitate recovery planning for ESA-listed salmonid stocks in California by providing information on costs associated with habitat restoration activities relevant to their recovery.

Data from publicly available sources were used to obtain estimates of restoration cost. Ideally these estimates would be identifiable to a specific restoration activity (e.g., fish screen, culvert replacement), include life cycle project costs (e.g., planning, design, permitting, construction, monitoring, maintenance), and be relatable to the scale, scope and location of the project. However, sources vary in terms of the extent to which they provide such details. Most cost estimates originate from sources generally intended for purposes other than recovery planning (e.g., contract administration). Thus reported costs may be incomplete if, for instance, some aspects of restoration are not covered by the contract or if the work involves a match from another funding source. For projects involving multiple restoration activities, costs are more typically broken down by input (e.g., labor, materials) than by activity. Given the diverse factors that affect restoration costs (see Allen *et al.* 2004) and the lack of standardization in available project and cost data, a meta-analysis of project costs as they relate to project characteristics was not possible. However, some of the sources do provide insights into factors affecting costs; to the extent that such information is available, it is briefly summarized in the tables below.

Many of the projects discussed in this report were funded by the California Department of Fish and Game (CDFG) as part of the Fisheries Restoration Grants Program and (to a lesser extent) the Klamath River Restoration Grant Program. The report is thus approximately organized according to the restoration categories used by these two programs. Restoration activities covered by this report are as follows:

- Fish ladders (FL)
- Fish passage at stream crossings (FP) - culvert replacement/improvement
- Fish screening of diversions (SC)
- Instream barrier modification (HB) - modification of fish passage barriers in the stream channel and along the streambank (tidegates, sandbars, dams, other non-culvert barriers)
- Instream habitat restoration (HI) - enhancement of stream channel and streambank habitat (instream structures, spawning gravel supplementation, floodplain tributary reconnection, side channel reconnection, wetland/floodplain restoration, levee evaluation/repair/setback)
- Riparian restoration - restoration of area, including fencing, between the fence and middle of stream (e.g., livestock exclusion, revegetation)

- Streambank stabilization (HS) - stabilization of eroding, collapsing of otherwise de-stabilized banks
- Upland watershed restoration (HU) - largely pertains to upslope erosion control (e.g., road decommissioning/upgrade, landslide/gully stabilization, upslope planting)
- Tailwater management (TM)
- Water conservation (WC) - e.g., ditch lining, piping
- Water purchase/lease (WP)
- Habitat acquisition and conservation easement (HA)
- Monitoring status and trends (MD) - monitoring of baseline conditions and status/trends in habitat, watershed processes and/or populations.
- Monitoring watershed restoration (MO) - monitoring to determine if project treatments were constructed correctly and as planned, effectiveness monitoring to determine if restoration has produced desired habitat conditions and/or watershed processes, and validation monitoring to determine if hypothesized responses of habitat, watershed processes and/or populations to restoration were correct
- Watershed evaluation, assessment and planning (PL) - developing watershed plans with site-specific, prioritized recommendations for restoration of salmon/steelhead habitat. Includes partial assessments (e.g., road erosion surveys, stream surveys).
- Watershed organizational support and assistance (OR) - organizational support to local watershed groups and development/maintenance of databases that facilitate organizational aspects of restoration
- Cooperative fish rearing (RE)
- Water measuring devices (WD) - e.g., head gate
- Wildlife management (WM) - e.g., control of exotic species such as pike minnow
- Research (RES) - general research on productivity (e.g., life cycle monitoring/analysis), spatial structure (fish distribution surveys), genetic diversity (laboratory analysis of tissue samples), and estimation of abundance.

Restoration cost estimates were obtained by searching the published and gray literature, including the following:

- reports that provide actual or estimated costs associated with specific projects (e.g., grant proposals, contract reports),
- reports that provide average costs for multiple projects involving the same restoration activity,
- reports that describe “typical” costs associated with a particular restoration activity,
- cost guidelines associated with environmental improvement programs sponsored by entities such as the Natural Resources Conservation Service (NRCS),
- reports that use regression and other methods to relate project costs to selected project characteristics, and
- environmental impact statements that provide cost estimates for each of the restoration alternatives considered.

Only restoration cost estimates that met at least one of the following criteria are included in this report:

- Top priority for inclusion are cost estimates pertaining to restoration activities in California. However, examples from other states are also included (as available) for those activities where California examples are limited. A notable exception: Cost estimates developed by Evergreen Funding Consultants for restoration in Puget Sound (Evergreen 2003) are particularly instructive, as they cover a wide range of restoration activities, provide life cycle estimates of project costs, and demonstrate how costs vary with project characteristics. Thus all of Evergreen's cost estimates are included in this report - even when they pertain to activities where a fairly large number of California examples are also available.

- Cost estimates are generally more useful for recovery planning when related to the scale of restoration. Thus only cost estimates that are accompanied by a relevant measure of project scale (e.g., stream miles, acres of land) are included in this report.

- For most projects involving multiple types of restoration activities, data sources typically do not provide a cost breakdown by activity. Given the focus of this report on activity-specific costs, most of the cost estimates were by necessity obtained from single-activity projects. However, to ensure some representation of multi-activity projects, some projects involving several closely related activities (e.g., fencing + stockwater system, fish ladder + screen) conducted at the same site are included in this report. Also, cost summaries provided by the Pacific States Marine Fisheries Commission for projects sponsored by CalFED's Ecosystem Restoration Program (Holycross *et al.* 2007) include some estimates of cost per activity for multi-activity projects.

- To help ensure that cost estimates reflect fairly recent restoration technology, the report focuses largely on projects that have occurred since 1998. However, in cases where project data for a particular restoration activity are sparse, pre-1998 project data are also provided, as available.

All costs described in this report pertain to direct expenditures on restoration and do not include economic opportunity costs (e.g., foregone profits associated with restrictions on livestock grazing, timber harvest and other activities). It is important to note the following:

- Even the direct costs described in this report are not necessarily comparable across projects, as some cost estimates are more inclusive than others. Some data sources - e.g., Evergreen Funding Consultants (2003), Neal (2004), Steere (2004) - provide cost estimates that include pre- and post-construction requirements as well as construction itself. In other cases, cost estimates are largely limited to engineering and/or implementation aspects of the project (e.g., CDFG's Fisheries Restoration Grants

Program, NRCS Environmental Quality Improvement Program) and do not include agency involvement in planning, design, management, maintenance and monitoring. In still other cases, documentation is not adequate to determine exactly what is included and excluded from the cost estimates.

- For most projects involving capital construction (e.g., bridges, fish screens), costs are not amortized but rather provided as a lump sum. One notable exception is the Independent Economic Analysis Board's (2002) estimates of amortized capital construction costs for Columbia River hatcheries.

For each restoration activity, one or more tables are provided that include cost estimates for that activity - by location, year, project scale, cost per scale unit, and data source.

- Depending on available information, each project example is variously identified by stream/creek/river, watershed, county, recovery domain,[1] or state.

- Depending on the source of a cost estimate, year may pertain to the year of a funding proposal or contract. In cases where a document includes cost estimates for projects conducted in years prior to publication of the document, the project year is used when available; otherwise the publication year is used.

- The metric used for project scale varies, depending on the nature of the restoration activity. Thus for instance, design approach velocity (cubic feet per second, cfs) is used for fish screens; linear feet for levee work, fencing, bank stabilization; acres for revegetation, wetland restoration, land purchase/easement; and miles for road decommissioning/upgrade.

- As indicated above, this report focuses largely on 1998-2006 projects. Cost estimates for these projects are provided in current dollars (uncorrected for inflation). In situations where paucity of 1998-2006 data warranted inclusion of pre-1998 projects, costs of pre-1998 projects were corrected to 2006 dollars. In some cases, the data sources themselves provide inflation-corrected cost estimates. The base year for these estimates is documented in this report, along with the year(s) when the restoration actually occurred (e.g., Hildner/Thomson's (2007a) results are denoted "98-05" and "2003$" to reflect the fact that their cost estimates are based on 1998-2005 project data and have been corrected to 2003 dollars).

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[1] The recovery domains include: Southern Oregon/Northern California Coast (SONC), North/Central California Coast (NOCECA), Central Valley, and South Central California Coast (SCACO). There is an area of geographic overlap between the SONC and NOCECA, which is referenced in this report as NOCECA-SONC.

- The nature of the cost estimates vary somewhat, depending on the data source: (i) In cases where cost is reported for a specific project, total project cost, project scale, and average cost per scale unit are provided, as available. (ii) In cases where cost is reported as an average value across multiple projects, the sample size and range of project costs (as available) are reported along with average cost. (iii) In cases where a "typical" cost is reported, the "typical" cost and the range of "typical" costs (as available) are provided. (iv) In cases where cost is estimated from a regression equation, the equation itself is provided as well as a range of fitted values associated with the regression parameters.

- In cases where management/administrative costs are reported for a multi-activity project and the cost estimate in the table pertains to one activity, management/administrative costs (which are not solely attributable to that one activity) are provided separately and not included in the calculation of cost per scale unit.

- Data sources are identified in the tables by last name or initials of author(s) and table and/or page numbers as appropriate. In cases where the data sources were grant proposals submitted to CDFG's Fisheries Restoration Grants Program (FRGP) or Klamath River Restoration Grant Program (KRRGP), those sources are identified in the tables by the fiscal year in which the proposal was submitted (01-02 through 06-07) and the project ID number (CDFG-xxx for the FRGP, Kxxx for the KRRGP). In cases where the data sources are projects sponsored by CALFED's Ecosystem Restoration Program (ERP), the projects are identified by the year of the proposal and the project ID (ERP-xx-xxx). In cases where costs associated with an ERP project could be broken down by activity, that project ID appears multiple times in the tables. All data sources are fully documented in the "References" section at the end of this report.

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FL - FISH LADDER.

Table FL-1 provides estimates of fish ladder costs. CDFG's Coho Recovery Strategy (CDFG'04, p1.14) assumed $500K/ladder on tributaries and $900K/ladder on streams. This cost range pertains to central/northern CA coastal streams and is not necessarily applicable to projects outside that geographic range. However, most of the projects in Table FL-1 do fall within that range. Notable exceptions (exceeding $2M/ladder) include a project in the South Central California Coast (SCACO) recovery domain (HT07a-T61, p121) and several Central Valley projects (HT07a-T61, p121, ERP-99-B03) . Note: Some of the projects pertain to ladders only, others to ladder/screen combinations.

Table FL-1. Fish Ladder ($/project)

Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	Small waterway (tributary): $500K/ladder Large waterway (stream): $900K/ladder	CDFG'04, p1.14
Young'sDam	03-04	1ladder	$494K - sloping plate, selfclean, excluding design	CDFG-057
SONC CentralVly SCACO	98-05 2003$	1site 1site 1site	$530.1K $2.1M $2.1M	HT07a-T61, p121
Gorrill Dam/Butte Creek	1997	2ladder	$660K ($330/ladder) +$12.8K project mgmt + $58.8K construction mgmt - construct ladder and screen	ERP-97-M03
Adams Dam/Butte Creek	1997	1ladder	$298.7K (+$6.3K project mgmt + $3K project coordination) - construct ladder and screen	ERP-97-M04
Battle/Soap/ Ripley Creeks	1999	3projs	$2.7M ($902.7K/project) - decommission several PG&E dams, provide ladders/ screens for remaining dams	ERP-99-B01
Sacramento River	1999	2 projs	$4.56M ($2.28M/project) + $130K project mgmt - Anderson-Cottonwood Irrig Dist	ERP-99-B03
Battle Creek	1999	1 proj	$731K +$105.3K project mgmt - improve CNFH fish ladder & barrier weir	ERP-99-B08

FP - FISH PASSAGE AT STREAM CROSSINGS.

Tables FP-1 and FP-2 pertain to culvert replacement, Table FP-3 to culvert replacement with a bridge, and Table FP-4 to culvert improvement.

Table FP-1 describes Evergreen's estimates of culvert replacement costs, while Table FP-2 provides similar estimates from other data sources. Evergreen's estimates include not only construction but also design, permitting, monitoring, maintenance and management, and are much more inclusive than the estimates in Table FP-2. Most of the latter examples are derived from grant proposals submitted to CDFG's Fisheries Restoration Grants Program - with costs largely limited to engineering/construction aspects of the project. The Table FP-2 estimates generally fall within the range of $100K-$400K/culvert, although there are some projects that cost in the $10,000s (e.g., Dupont-T10, p66; HT07a-T60, p118; HT07a-T61, p121) and one very costly project ($4.1M, CntySBPublicWrks) in Santa Barbara. Culvert type is reported here when available from the data source.

Evergreen's estimates show typical culvert replacement costs for Puget Sound by road type and size of waterway.Like Evergreen, Hildner/Thomson show cost per culvert being lower for rural roads than major highways (HT07b-T42, p61) and increasing with stream order (HT07b-T44, p62). Excluding 4+ lane highways (which are not covered by Hildner/Thomson), the estimates obtained by HT from restoration contractors fall within Evergreen's cost ranges. E.g., forest roads - Evergreen: $15K-$150K, HT: $23.4K; minor 2 lane road - Evergreen: $50K-$280K, HT: $227K; major 2 lane road - Evergreen: $100K-$450K, HT: $420K. Small waterway - Evergreen: $15K-$200K, HT: $70K; medium waterway - Evergreen: $50K-$350K, HT: $175K; large waterway - Evergreen: $80K-$450K, HT: $286K.

Table FP-1. Culvert Replacement - $/project (Source: Evergreen 2003, p. 21)
Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management

Size of Waterway	Road Type			
	Forest Road	Minor 2 Lane	Major 2 Lane	Hwy 4+ Lane
Small 0-10'	$15K-40K	$50K-100K	$100K-200K	$200K-350K
Med 10-20'	$50K-100K	$140K-240K	$200K-350K	$300K-450K
Large 20-30'	$80K-150K	$180K-280K	$250K-450K	$600K-800K

Table FP-2. Culvert Replacement - $/project				
Location	Year	Units	Cost Per Unit	Source
AlbionR/Marsh Crk-MendcnoCnty	01-02	3culvrt	$180.5K ($60.2K/culvert)	CDFG-007
PeacockCrk-DelNorteCnty		1culvrt	$295.0K - open bottom	CDFG-009
JohnsonCrk-MendcnoCnty		1culvrt	$100.9K - bottomless pipe arch	CDFG-009
DeerCrk-MendcnoCnty		1culvrt	$97.5K - bottomless pipe arch	CDFG-010
JordanCrk-DelNorteCnty		1culvrt	$246.3K - box culvert	CDFG-059
RyanCrk-MendcnoCnty		1culvrt	$151.5K - bottomless pipe arch	CDFG-068
PorterCrk-RussianR	02-03	2 culvrt	$266,250 ($133.1K/culvert)	CDFG-028
StansberryCrk-MattoleR		1culvrt	$197.5K	CDFG-265
GibsonCrk-MattoleR		1culvrt	$213.1K	CDFG-266
StanleyCrk-MattoleR		1culvrt	$239.4K	CDFG-267
SaundersCrk-MattoleR		1culvrt	$269.5K	CDFG-268
IndianCrk-MattoleR		1culvrt	$55.0K	CDFG-270
DarkGulch-MndocnoCnty		1culvrt	$202.1K	CDFG-305

AlbionR/Marsh Crk-MendcnoCnty RyanCrk-MendocnoCnty JohnsonCrk-BigR-MendocnoCnty YonkersCrk-DelNorteCnty GrahamGulch-HumboldtCnty PainterCrk-MattoleR-HumboldtCnty SoldierCrk-TrinityR-TrinityCnty	03-04	2culvrt 1culvrt 1culvrt 1culvrt 1culvrt 1culvrt 2culvrt	$299,592 ($149.8K/culvert) - natural bottom pipe arch $278.8K - natural bottom pipe arch $128.1K - natural bottom pipe arch $242.6K - bottomless arch $245.8K - bottomless multiplate arch $246.2K - bottomless multiplate arch $305.3K ($152.7K/culvert)	CDFG-098 CDFG-099 CDFG-104 CDFG-149 CDFG-165 CDFG-166 CDFG-236
BatesCanyonCrk-MarinCnty WarrenCrk-MadR-HumboldtCnty	04-05	1culvrt 1culvrt	$208.4K $326.3K - bottomless multiplate arch	CDFG-026 CDFG-233
WardenCrk-EelR-HumboldtCnty RockyGulch-HumboldtCnty	05-06	1culvrt 2culvrt	$44.5K - bottomless arch $381.6K ($190.8K/culvert) - embedded structural plate metal box culvert	CDFG-062 CDFG-137
CA	98-05 2003 $	3culvrt	$13.3K ($1.9K-$24.2K)	HT07a-T60, p118
SONC SONC-NOCECA SCACO	98-05 2003 $	1culvrt 1culvrt 1culvrt	$1.9K $13.9K $24.2K	HT07a-T61, p121
CA CA CA	02-04	27clvrt 13clvrt 1culvrt	<u>Road Type:</u> ForestRoad: $23.4K ($379-$217.9K) Minor2Lane: $227.1K ($5.1K-$412.8K) Major2Lane: $420.4K	HT07b-T42, p61,contrctr
CA CA CA	02-04	30clvrt 8clvrt 1culvrt	<u>Stream Order:</u> 1st order: $70.4K ($970-$420.4K) 2nd order: $175.4K ($851-$412.8K 3rd order+: $285.5K	HT07b-T44, p62,contrctr

CA CA	02-04	7culvrt 11clvrt	Culvert Type: Open-btm arch:$262.8K ($124K-$401K) Pipe: $7.4K ($970-$17.2K)	HT07b-T49, p71,contrctr
Sta Ynez	07-12	2culvrt	$8.11M ($4.1M/culvert, reinforced concrete box culvert)	CntySB PublicWrks
Idaho		1culvrt	$15K-$25K - bottomless arch, 30-60 yrs $8K-$20K - buried culvert, 20-50 yrs $500-$5K - ford	Dupont-T10, p66

Costs of culvert replacement with bridge described in Table FP-3 generally range from $100K to $500K/bridge. A few projects cost <$50K (e.g., 02-03 CDFG-065; 03-04 CDFG-201 & CDFG-311; 05-06 CDFG-077; Dupont-T9, p65). Projects that cost >$650K all occurred in southern or south-central California (04-05 CDFG-031 & CDFG-241; 06-07 CDFG-090). Information on bridge type - which is reported here when available from the data source - suggests that prefabricated bridges fall toward the lower end of the cost spectrum. Dupont provides information on expected lifetime of various types of bridges, although his information pertains to Idaho rather than California.

Table FP-3. Culvert Replacement with Bridge ($/project)

Location	Year	Units	Cost Per Unit	Source
JohnSmithCrk-MendcnoCnty	01-02	1bridge	$189.5K - flat car bridge	CDFG-043
HayworthCrk-MendocnoCnty		2bridge	$89,711 ($44.9K/bridge)	CDFG-060
ApanolioCyn-SanMateoCnty	02-03	1bridge	$250K - 3sided bridge	CDFG-015
OldCreekRd-VenturaR			$111.5K	CDFG-038
SoFork CottanevaCrk-MendcnoCnty			$22.6K	CDFG-065
TrinityR			$500K	CDFG-119
KellyGulch-SiskiyouCnty			$163.2K	CDFG-284

FrenchmansCrk-SanMateoCnty FrykmanGulch-BigR-MendcnoCnty IndianCrk-HumboldtCnty LindsayCrk-MadR QuarryBridge-GualalaR	03-04	1bridge	$130.2K - clear span bridge $77.6K $437.3K $26.0K - manufactured $46.0K - 45' modular	CDFG-028 CDFG-052 CDFG-168 CDFG-201 CDFG-311
ArroyoSecoR-MontereyCnty CampCrk-NavarroR-MendcnoCnty O'NeilCrk-KlamathR-SiskiyouCnty SolsticeCrk-LA	04-05	1bridge	$1.5M $234.6K - includes rock weirs $100K - concrete, single span $653.3K - precast open bottom	CDFG-031 CDFG-041 CDFG-064 CDFG-241
LindsayCrk-MadR-HumboldtCnty CedarCrk-SmithR-DelNorteCnty	05-06	1bridge	$54K $347.9K	CDFG-077 CDFG-269
StaRosaCrk-SanLuisObispo SoquelCrk-StaCruzCnty	06-07	1bridge	$746.3K $409.6K	CDFG-090 CDFG-195
HorseCrk-Klamath	06-07	1bridge	$230.5K	K002
Idaho	2000	typical	<u>Bridge Type:</u> Wood stringer, 25-50yr lifetime: $10-$20K Prefab concrete, 40-60yr lifetime: $15K-$25K Railroad, 40-60yr lifetime: $15K-$30K Steel/concrete, 50-75yr lifetime: $30K-$50K	Dupont-T9, p65
SONC	98-05 2003$	1site	$109.6K	HT07a-T61, p121

CA	02-04	6sites	$217.9K ($23K-$420.4K)	HT07b-T49, p71,contrctr
CA	98-05 2003$	2sites	$261.3K ($22.7K-$500K)	HT07b-T41, p59,CHRPD
CA	FY07	typical	Bridge Size: >40ft: $100K <40 ft, flatbed railroad: $50K	NRCS

Most of the culvert improvement costs described in Table FP-4 range from about $5K to $65K. The two notable exceptions are $463.1K (03-04 CDFG-320) and $485K (05-06 CDFG-162) - both of which seemed to also involve substantial habitat work around the culvert. The NRCS examples pertain to culvert removal rather than improvement, but are included here in case such actions are considered for farmland in recovery planning.

Table FP-4. Existing Culvert Improvement - $/project

Location	Year	Units	Cost Per Unit	Source
JollyGiantCrk -Arcata	01-02	1culvrt	$10.2K	CDFG-124
SoForkBigR-MendcnoCnty	02-03	1culvrt	$23.3K	CDFG-286
ElCapitanCrk -StaBarbCnty	03-04	1culvrt	$463.1K - baffles, replace culvert floor, construct pools	CDFG-320
BrownsCrk-PajaroR-StaCruzCnty	04-05	1culvrt	$65.5K - replace floor, add weirs	CDFG-068
ChaddCrk-EelR-HmboldtCnty	05-06	1culvrt	$485K - 9.5 ft dia steel plate culvert, retrofit w/baffles & jump pools	CDFG-162
Idaho	2000	1culvrt	Culvert Type: Angle iron fish ladder: $1,185 Chimney block fish ladder - $375 Baffles - $2,530 Downstream drop structure - $1,180	 Dupont-T1, p59 Dupont-T2, p60 Dupont-T3, p60 Dupont-T4, p61
NOCECA	98-05 2003$	1site	$4.7K/baffle	HT07a-T61,p121

CA	02-04	1culvrt	Culvert Type: Boulder weir: $13.3K Baffles: $17.9K Other: $575	HT07b-T50, p74,contrctr
CA	98-05 2003$	2culvrt	$9.4K ($4.7K/culvert) - baffle	HT07b-T51, p74,CHRPD
Sonoma Crk	2000	1culvrt	$21.6K	ERP-00-E04

SC - FISH SCREENING OF DIVERSIONS

Table SC-1 provides cost estimates for fish screens relative to the design approach velocity of the screen (cubic feet per second, cfs). Cost of screens produced by the CDFG screen shop range from $2K to $10K/cfs (BM, p. J-3). Most of the other cost estimates in the table fall within this range. Some notable exceptions include projects on the Klamath River (e.g., 05-06 CDFG-200) and in the Central Valley (e.g., ERP-00-B02, ERP-95-M05, ERP-96-07, ERP-97-C01, ERP-97-M07).

Table SC-1. Fish Screen - $/cfs, $/screen

Location	Year	Units	Cost Per Unit	Source
CA	2005	typical	$2K-$10K/cfs (CDFG screen shop)	BM, pJ-3
KlamathR KlamathR KlamathR	05-06	15.3cfs 3.51cfs 1.2cfs	$99,173/screen ($6.5K/cfs) - self clean $39,758/screen ($11.3K/cfs) $29,961/screen ($25K/cfs) - design/install preexisting tube screen	CDFG-049 CDFG-173 CDFG-200
CA	2004	typical	Type of Waterway: Small tributary: $10K/screen Large stream: $40K/screen	CDFG'04, p1.15
CalFED	2000	4scrns 1scrn	Flow Range: 350-800cfs: $8.5K-$15K/cfs 15-20cfs: $100K ($3.3K-$5K/cfs)	Hayes-Fig2,p174 Hayes-p183

WA	2000	Sample of 1-15cfs screens Sample of 1-58cfs screens Sample of 1-210cfs screens	***Figure 2: C=6060.4 cfs ^1.2405*** 2cfs: $14,320/screen ($7.2K/cfs) 4cfs: $33,834/screen ($8.5K/cfs) 6cfs: $55,950/screen ($9.3K/cfs) 8cfs: $79,944/screen ($10K/cfs) 10cfs: $105,439/screen ($10.5K/cfs) 12cfs: $132,198/screen ($11K/cfs) 14cfs: $160,056/screen ($11.4K/cfs) ***Figure 3: C=8221.2 cfs ^ 1.0108*** 10cfs: $84,282/screen ($8.4K/cfs) 20cfs: $169,831/screen ($8.5K/cfs) 30cfs: $255,864/screen ($9K/cfs) 40cfs: $342,214/screen ($8.6K/cfs) 50cfs: $428,799/screen ($8.6K/cfs) 60cfs: $515,573/screen ($8.6K/cfs) ***Figure 4: C=11083 cfs ^ 0.9025*** 50cfs: $344,279/screen ($6.9K/cfs) 100cfs: $643,561/screen ($6.4K/cfs) 150cfs: $927,923/screen ($6.2K/cfs) 200cfs: $1,203.010/screen ($6K/cfs)	Hudson-p192 Hudson-p192 Hudson-p193
OR	2000	12scrns 4scrns 3scrns 3scrns 2scrns 10scrns 10scrns	<u>Screen Type, Flow Range*:</u> Rotary drum, 0.4-25 cfs: $1.3K-$11.3K/cfs Rotary drum prefab, 0.8-2cfs: $3.9K-$9.4K/cfs Belt, 10cfs: $2.3K-$3.2K/cfs Panel, 12-30cfs: $2.8-$3.1K/cfs Pump, low veloc, 0.5-1.8cfs: $0.8K-$1.9K/cfs Pump, Clemons, 0.6-4.2cfs: $0.5K-$2.2K/cfs Pump, SureFlo, 0.5-6cfs: $0.5K-$2.5K/cfs	Kepshire-T1, p207
* Engineering costs incurred only for screens >25 cfs.				
CA farmland	FY07	typical	<u>Flow Range*:</u> <1cfs: $2K/screen ($2K/.5cfs=$4K/cfs) 1-5cfs: $6K/screen ($6K/2.5cfs=$2.4K/cfs) 5.1-10cfs: $14K/scrn ($14K/7.5cfs=$1.9K/cfs) >10cfs: $20K/screen (<$2K/cfs) * $/cfs estimated using midpoint of cfs range	NRCS CA

WA	1999$	16scrns 19scrns 5scrns 7scrns 5scrns	Flow Range: 1-10cfs: $3.6K-$17.8K/cfs 10-50cfs: $4.5K-$16.6K/cfs 50-100cfs: $4.5K-$9.8K/cfs 100-1000cfs: $2.4K-$7.0K/cfs >1000cfs: $2.0K-$7.0K/cfs	WDFW
Sacrmnto River	2000	1 scrn	$435.4K (44.6 cfs screen, $10K/cfs) - Pump Station #1	ERP-00-B01
Sacrmnto River	2000	1 scrn	$303K +5K project mgmt + $2.5K project coordination + $59.6K engineering design (20 cfs screen, $15K/cfs) Tuttle Pump Relocation Project	ERP-00-B02
Amer/Sacramento R	2001	2 projcts	$40.4M + $750K project mgmt + $3.1M construction mgmt ($20.2M/screen) - replace intake SacR Water Treatment Plant, replace screen EA Fairbairn Water Treatment Plant.	ERP-01-N51
Sacrmnto River	2001	10scrns 8-39cfs	$1.1M + $521.7K program admin/mgmt/ coordination ($111.7K/screen)	ERP-01-N52
Sacrmnto River	1995	1 projct 150 cfs	$3.2M + $100K project mgmt + $173K construction mgmt ($21.3K/cfs) - decommission old diversion at M&T Ranches' Parrot-Phelan Pumping Station, relocate/construct/screen new diversion	ERP-95-M05
Suisun Marsh	1995	5 screens	$765.3K ($153.1K/screen) Phase 1 - diversion evaluation & selection	ERP-95-M07
Sacrmnto River	1996	1 projct 600 cfs	$9.4M + $698.3K project coordination ($15.7K/cfs) - consolidate 3 diversions into 1 new diversion, Princeton-Codora-Glenn Irrig Dist & Provident Irrig District	ERP-96-07
Yuba River	1996	1 projct 65 cfs	$202K ($3.1K/cfs) - Browns Valley Irrig District	ERP-96-M17
Sacrmnto River	1997	1 projct 700 cfs	$10.4M ($14.0K/cfs) - Reclamation District 108's diversion structure at Wilkins Slough	ERP-97-C01
Butte Creek	1997	1 projct 162 cfs	$660.3K + $12.8K project mgmt + $58.8K construction mgmt ($4.1K/cfs) - Gorrill Dam	ERP-97-M03

Butte Creek	1997	1 projct 135 cfs	$515.9K + $6.3K project mgmt + $3K project coordination ($3.8K/cfs) - Adams Dam	ERP-97-M04
San Joaquin R	1997	1 projct 250 cfs	$7.6M + $62K project mgmt + $411K construction mgmt + $154K post-construction services ($30.4K/cfs) - vertical V fish screen, Banta-Carbona Irrig District	ERP-97-M07
Sacrmnto River	1998	1 projct 22 cfs	$270.5K ($12.3K/cfs) - Boeger Family Farm Fish Screen Phase II: Construction	ERP-98-B26
Lindsay Slough/ Cache Slough	1998	1 projct 53 cfs	$416K ($7.8K/cfs) - Hastings Tract Fish Screen Phase II: Construction	ERP-98-B27
Battle/ Soap/ Ripley Creeks	1999	1 projct	$1.06M (3 screens - 55 cfs, 70 cfs, 220 cfs; $3.1K/cfs) - decommission several PG&E diversion dams, provide ladders/screens for those that remain	ERP-99-B01
Sacrmnto River	1999	1 projct 450 cfs	$4.56M + $130K project mgmt ($10.1K/cfs) - ACID Fish Screen Phase III: Construction	ERP-99-B03
Sacrmnto River	1999	1 projct 960 cfs	$6.222M ($6.5K/cfs) - Tisdale Positive Barrier Phase IV: Construction/Performance Eval	ERP-02D-P70

HB - INSTREAM BARRIER MODIFICATION FOR FISH PASSAGE

This section covers modification of non-culvert fish passage barriers in the stream channel and along the stream bank. Table HB-1 focuses on tide gates, Table HB-2 on sandbars, Table HB-3 on dam,, and Table HB-4 on other barriers.

Based on a limited number of examples, the replacement cost of a tide gate is ~$105K; retrofit cost is $26K.

Table HB-1. Tide Gates - $/unit				
Location	Year	Units	Cost Per Unit	Source
HumboldtBay	03-04	3 tidegates	$317,148 ($105.7K/tidegate) - replace 2 tidegates & add 3rd	CDFG-143
HumboldtBay	2005	1 tidegate	Retrofit: $26K	MA, p2

Based on a single example, cost of sandbar breaching is $13K/breaching.

Table HB-2. Sandbar Breaching - $/unit				
Location	Year	Units	Cost Per Unit	Source
Estero de San Antonio (MarinCnty)	1993	1breaching	$10K/breaching *(2006$: $13.1K)* - incl equip rental	WC, p19

Based on a single example, cost of dam decommission is $1.5M.

Table HB-3. Dam Decommission/Removal - $/unit				
Location	Year	Units	Cost Per Unit	Source
BattleCrk/SoapCrk/ RipleyCrk	1999	5 dams	$7.53M ($1.5M/decommission)	ERP-99-B01

Barrier modification projects identified in Table HB-4 typically involve weirs, head gates, fish screens and/or measuring structures. Most of the modifications cost $30K-$170K, with the exception of two $1M+ barrier removal/fish screen projects on the Shasta River (06-07 K010 & K011). A single estimate of weir repair cost is provided: $10.8K/weir (06-07 K034).

Table HB-4. Other Non-Culvert Barrier Modification - $/unit				
Location	Year	Units	Cost Per Unit	Source
EastForkScott/French Crk/ShacklefordCrk// ScottR-KlamathRiver	06-07	13 barriers	$962.9K ($74.1K/barrier) - remove seasonal barriers/install head gate to measure diversion volume	K025
ShastaR-Klamath	06-07	1 barrier	$1356.5K - remove barrier/install fish screen	K010
ShastaR-Klamath	06-07	1 barrier	$981.9K - remove barrier/install fish screen	K011
ColdCrk-KlamathR	06-07	1 barrier	$65.1K - replace diversion w/fish passable weir, update screen	K014
ShastaR-Klamath	06-07	4 barriers	$120.9K ($30.2K/barrier) - replace 2 barriers w/boulder weirs; install head gate/fish screen/measuring weir on 2 unscreened diversions	K023
Scott-KlamathR	06-07	1 barrier	$170K - replace barrier with boulder weirs/head gate/ measuring structure	K032
FrenchCrk/MinersCrk/ PattersonCrk/ ShackefordCrk-KlamathR	06-07	6 weirs	$65K (10.8K/weir) - repair storm-damaged secondary weirs in 6 locations	K034
Guadalupe River (So SanFran Bay)	1998	2 passage structures	$147.9K ($74K/structure)	ERP-98-B23
Carriger Creek (Sonoma Creek)	2001	1 barrier	$67.6K - boulder weir ladder	ERP-01-N27

HI - INSTREAM HABITAT RESTORATION

This section covers restoration of instream habitat. Tables HI-1 & HI-2 pertain to instream structures such as wood/boulder structures and large woody debris, Table HI-3 to spawning gravel supplementation, Table HI-4 to floodplain tributary reconnection, Tables HI-5 and HI-6 to channel restoration, and Table HI-7 to wetland/floodplain restoration.

Evergreen (Table HI-1) estimates restoration costs for small/medium streams with small/medium transportation & material requirements on a per-mile basis, and estimates costs for large streams with medium/high transportation & material requirements on a per-structure basis. The examples in Table HI-2 also represent a mixture of per-mile and per-structure estimates; however, the units of measure in Table HI-2 were not based on any systematic criterion (as per Evergreen) but rather reflect whatever units were available from each data source. Cost-per-mile tends to be lower using Evergreen's estimates ($10K-$50K/mile) than the Table HI-2 estimates, which ranged from ~$25K to $500K/mile (with the exception of a $1.4M/mile project (01-02 CDFG-156) where cost per mile was derived by expanding the cost of that 40' project to an entire mile). Conversely cost-per-structure tends to be higher using Evergreen's estimates ($10K-$80K/structure) than the Table HI-2 estimates (~$500-$11K/structure). These results are not surprising, given that Evergreen systematically applied cost-per-mile to lower-cost projects and cost-per-structure to higher-cost projects.

Table HI-1. Engineered Logjams and Large Woody Debris - $/structure, $/stream mile (Source: Evergreen 2003, p. 25)

Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management costs. All estimates assume purchased materials.

Stream Size (cfs)	Transportation & Material Requirements		
	Low Cost	Medium Cost	High Cost
Small 1-100 cfs	$10K-30K*	$20K-50K*	$20K-40K
Med 100-2000 cfs	$20K-50K*	$15K-45K	$40K-70K
Lge 2000+ cfs	$10K-20K	$40K-60K	$60K-80K

* Cost per stream mile, assuming 100-400 pieces per stream mile. Estimates in all other cells measured as cost per structure.

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Table HI-2. Instream Structures - $/mile, $/structure				
Location	Year	Units	Cost Per Unit	Source
WindR-WA	2000	typical 1 project 1 project	Channel rehab: $86K ($41K-$137K)/mi Onsite material: $65K/mi Imported material: $140K-$160K/mi	Bair-pp107-108
UpperMattoleR-HumboldtCnty EelR LowerSodaCrk-EelR-MndcnoCnty	01-02	12 strctrs 40' 640'	$23,507 ($1959/structure) - log $10,979 ($1.4M/mi) $54,329 ($448.8K/mi)	CDFG-048 CDFG-156 CDFG-258
FelizCrk-RussianRiver MoonCrk-KlamathR-DelNorteCnty	02-03	1300' 15 strctrs	$20,580 ($83.7K/mi) $40,600 ($2707/structure)	CDFG-011 CDFG-127
HayworthCrk/NFNoyoR-MendcnoCnty UpperMattole-HumboldtCnty	03-04	55 strctrs 14 strctrs	$30,422 ($553/structure) $36,510($2608/structure) - wood/boulder	CDFG-216 CDFG-233
SultanCrk-SmithR-DelNorteCnty WilsonCrk-DelNorteCnty RedwoodCrk-RussianR-SonomaCnty	04-05	10 strctrs 10 strctrs 1.08 mi	$20,497 ($2050/structure) $25,998 ($2600/structure) $60,419 ($55.9K/mi)	CDFG-143 CDFG-145 CDFG-247
EelR DelNorteCnty	06-07	4.5 mi 10 strctrs	$112,437 ($25K/mi) $46,753 ($4675/struc) - +1000 native conifers to replenish wood instream	CDFG-056 CDFG-110

CA	2004	typical	<u>Distance from Road:</u> 0.25-0.5mi: $26K/mi 1-2mi: $27K/mi 2-3mi: $28K/mi >3mi: $29K/mi	CDFG'04 p1.24
TectahCrk-KlamathR	06–07	5 mi	$275.4K ($55.1K/mi) - LWD construction/placement with helicopter	K003
ScottR-Klamath	06-07	6-8 major structures	$65.8K ($8.2K-$11K/structure)	K037
CA		37projcts	20 struc/mi: $25.3K ($5.6K-$70.8K)/mi, $1762/structure)	Hampton-T1, pp122-123
CA		37projcts	***$/mile=24,482+427*#structures/mi*** 20 struc/mi: $33.0K/mi 50 struc/mi: $45.8K/mi 100 struc/mi: $67.2K/mi 200 struc/mi: $109.9K/mi 300 struc/mi: $152.6K/mi 400 struc/mi: $195.3K/mi	Hampton-p124
CA	98-05 2003$	24 sites 5 sites	$2.5K ($214-$11.3K)/structure $364.5K ($220.5K-$552.1K)/mi	HT07a-T60, p118
SONC SONC-NOCECA NOCECA NOCECA SCACO SCACO	98-05 2003$	3 sites 5 sites 1 site 15 sites 4 sites 1 site	$1.3K ($214-$2.1K)/structure $3K ($2.4K-$3.5K)/structure $534.1K/mi $2K ($680-$4.1K)/structure $322K ($220.5-$552.1K)/mi $11.3K/structure	HT07a-T61, p121
CA	02-04	58 sites	$12,375 ($250-$175K)/structure	HT07b-T53, p74,contrctr
CA	02-04	45 sites	$2.2M ($4K-$46.8M)/mi	HT07b-T54, p75,contrctr
OR-priv forest OR-state forest OR-USFS	2000	typical	<u>Assume 120 trees/mile:</u> $77.6K/mi - non-contract $82.4K/mi - contract $47.6K/mi - LWD-helicopter	Lacy-p139 Lacy-p139 Lacy-p140
King County, WA		600'	$113.5K ($99.8K/mi)	Neal-T4, p163

Table HI-3 pertains to spawning gravel supplementation. The WDFW example (WDFW-T3, p14), which is actually based on a British Columbia data source, estimates cost of spawning gravel supplementation at $20-$40/cubic yard. With the notable exception of the Stanislaus River project (ERP-97-N21) - where costs include evaluation as well as gravel treatment - the Central Valley examples indicate a range of costs ($11-$36/cubic yard) similar to WDFW's.

Table HI-3. Spawning Gravel Supplementation - $/cubic yard (cy)				
Location	Year	Units	Cost Per Unit	Source
WA	2004	typical	Gravel placement: $50-$70/m^3* Sorted gravel: $20-$40/cubic yard	WDFW-T3, p14
* Gravel placement - sorted gravel supplied, limited delivery distance, machine placed, does not include control structures.				
Tuolumne River	2002	10K cy	$3.59M + $50K project mgmt/admin ($36/cy)	ERP-02-P29
Sacramento River	1995	4964 cy	$52.5K ($11/cy)	ERP-95-M04
Tuolumne River	1997	6632 cy	$191.2K ($20/cy)	ERP-97-C11
Stanislaus River	1997	9220 cy	$667.9K ($72/cy) - Knights Ferry, incl evaluation of effects of diff size/sources of gravel on habitat utilization	ERP-97-N21

Tables HI-4 and HI-5 describe Evergreen's cost estimates for floodplain tributary reconnection (which vary with material and earthmoving requirements) and sidechannel reconnection (which vary with earthmoving requirements and energy of waterway).

Table HI-4. Floodplain Tributary Reconnection - $/acre
(Source: Evergreen 2003, p. 39)

Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management.

Materials	Extent of Earthmoving		
	Minimal	Moderate	Substantial
Minimal	$5K-10K	$10K-20K	$30K-40K
Moderate	$10K-20K	$20K-30K	$40K-60K
Substantial	$30K-40K	$40K-60K	$60K-80K

Table HI-5. Side Channel Reconnection - $/acre (Source: Evergreen 2003, p. 41)

Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management.

Extent of Earthmoving	Energy of Waterway		
	Low	Medium	High
Minimal/Near	$20K-40K	$40K-70K	$60K-90K
Moderate/Avg Distance	$40K-60K	$70K-100K	$100K-200K
Substantial/Far	$60K-100K	$130K-200K	$200K-300K

Table HI-6 provides cost estimates for channel restoration projects. All estimates pertain to Central Valley rivers and range from $1.2M/mile (ERP-99-B01) to $8.7M/mile (ERP-97-M08).

Table HI-6. Channel Restoration - $/mile				
Location	Year	Unit	Cost per Unit	Source
Merced River	1999	2.19 mi	$2.635M ($1.2M/mi) - large-scale reach restoration-channel realignment/floodplain creation	ERP-99-B01
Tuolumne River	2002	1.2 mi	$8.29M + $74.1K construction mgmt ($6.9M/mile) - large-scale reach restoration-channel realignment/floodplain creation	ERP-02-P19-D
Tuolumne River	1997	0.23 mi	$2.011M + $174K construction/proj mgmt ($8.7M/mile) - restore natural channel morphology	ERP-97-M08
Tuolumne River	1997	2.6 mi	$5.054M + $284 construction mgmt ($1.9M/mile) - restore natural channel morphology	ERP-97-M09
Tuolumne River	1998	2.2 mi	$5.054M ($2.3M/mile) - restore natural channel processes & habitats	ERP-98-F06
Merced River	1998	2.2 mi	$3.635M ($1.7M/mile) - restore natural channel processes & habitats	ERP-98-F11

Most of the wetland restoration cost estimates in Table HI-7 pertain to San Francisco Bay/Estuary; several estimates of annual operations & maintenance (O&M) and monitoring costs are included. Steere's information is notable in that he provides estimates by wetland type. The NRCS estimates indicate much lower wetland restoration costs for farmland ($75-$375/acre); these projects are likely much more modest in scale than the types of projects that occur in San Francisco Bay.

Table HI-7. Wetland Restoration - $/acre				
Location	Year	Units	Cost per Unit	Source
Topanga Crk-LA	05-06	12acres	$249.8K ($20.8K/acre) - remove 26Ktons of lead contaminated fill matl	CDFG-029
SF Bay/ Estuary	1995	typical	$20K-$30K/acre, up to $80K/acre *(2006$: $25K-$38K/acre, up to $101K/acre)*	Anon '95

SF Bay/ Estuary	2000	typical	<u>Wetland Type:</u> Tidal wetland: $5K-$100K/acre Seasonal wetland: $9K/acre (large-scale project) Wetland enhancement: $1K/acre (reveg, exotic species removal, limited irrig, modest mgmt) Monitoring: $500/acre for 5 yrs	Steere, pp231-233
SF Bay/ Estuary	1999	5 sites	(1) 500 acre wetland: $14K/acre/yr for 5 yrs, $35K/yr thereafter (land acquisition =$5M, planning/permitting=$250K, construction=$1.3M,monitoring=$25K/yr for 5 yrs, O&M=$35K/yr) (2) $1K/acre (restore tidal action to salt pond) (3) $18K/acre (seasonal/tidal wetland) (4) $27K/acre (levee construction/repair, extensive dredging) (5) $56K/acre (highly engineered, large soil volume, channel excavation, low berms)	USEPA '99, p170 USEPA '99, p172 " " "
CA farmland	FY07	typical	Light: $75/acre Moderate: $187.50/acre Intensive: $375/acre	NRCS

HR - RIPARIAN RESTORATION

This section covers restoration of erosion-prone banks adjacent to the stream and within the riparian corridor. Riparian area is defined as the area, including any necessary fencing, between the fence and the middle of the stream. Table HR-1 pertains to fencing/livestock exclusion, Table HR-2 to fence maintenance, Tables HR-3 and HR-4 to riparian planting, Table HR-5 to irrigation, and Table HR-6 to invasive/noxious weed control.

As indicated in Table HR-1, Evergreen (Evergrn p11) estimates fence construction costs at $1-$12/foot, with an "overall average" of $3-12/foot. CDFG's Coho Recovery Strategy (CDFG'04, p1.20) uses the midpoint of this latter range ($8/foot). Cost of all individual fencing projects (CDFG-xxx, HT07a, HT07b, NRCS CA) are expressed in $ per foot, even for projects that also include components other than fencing (e.g., revegetation, irrigation, stock water systems). For most of these projects (even those with added components), costs generally fall within the $1-$12/foot range indicated by Evergreen.

Table HR-1. Fencing/Livestock Exclusion - $/foot

Location	Year	Units	Cost Per Unit	Source
Puget Snd	2003	typical	Fence Material: Simple: $1-$4/ft Average: $5-$8/ft Complex: $9-$12/ft Overall Average: $3-$12/ft	Evergrn p11
CA	2004	typical	$8/ft	CDFG'04, p1.20
ShastaR	01-02	7800'	$56.6K ($7.26/ft, 7800' fence, 6 stockwater areas)	CDFG-065
EelR EelR EelR SLO Cnty TrinityCnty ShastaR ShastaR	02-03	1.1 mi 2 mi 3.5 mi 7600' 1 mi 1250' 850'	$40,800 ($7.02/ft) $19,993 ($1.89/ft) $28,664 ($1.55/ft) $56.4K ($7.42/ft; fencing, alternative water sources for cattle, riparian planting, temporary irrigation) $31,138 ($5.90/ft) $7,032 ($5.63/ft, +10yr maint & grazing exclusion) $4963 ($5.84/ft, +10yr maint & grazing exclusion)	CDFG-026 CDFG-116 CDFG-193 CDFG-243 CDFG-251 CDFG-324 CDFG-342
SmithR (dairy) RussianR	03-04	2K' 800'	$32,890 ($16.45/ft, incl riparian plant) $6.7K ($8.40/ft; fencing, water pump in stream to provide water for livestock)	CDFG-131 CDFG-195
ShastaR ShastaR ShastaR	04-05	13,500' 25,000' 3200'	$91,944 ($6.81/ft,native plants 1,685') $116,674 ($4.70/ft) $61,604 ($19.25/ft)	CDFG-194 CDFG-231 CDFG-243
SmithR KlamathR KlamathR	05-06	3000' 2600' 3600'	$21,259 ($7.09/ft, native trees) $17,494 ($6.73/ft, trees 3 acres) $25,850 ($7.18/ft)	CDFG-046 CDFG-188 CDFG-266

ShastaR	06-07	3500'	$28,213 ($8.06/ft, riparian veg)	CDFG-078
CA	98-05 2003$	10 sites	$7 ($2.43-$22.07)/ft - $37K/mi	HT07a-T60, p118
SONC SONC-NOCECA SCACO	98-05 2003$	6 sites 3 sites 1 site	$9 ($4.58-$22.07)/ft - $48.1K/mi $3.39 ($2.43-$4.89)/ft - $7.9K/mi $5.15/ft - $27.2K/mi	HT07a-T61, p121
CA	02-04	 2 sites 7 sites 2 sites	<u>Fence Material:</u> Simple: $1.89 ($0.79-$3.00)/ft Avg: $4.32 ($2.00-$7.00)/ft Complex: $4.72 ($3.44-$6.00)/ft	HT07b-T13, p34,contrctr
CA	98-05 2003$	9 sites	$7.24 ($2.43-$22.07)/ft	HT07b-T12, p33, CHRPD
CA	FY07	typical	<u>Fence Material:</u> Conventional: $3/ft Conventional extreme terrain: $8/ft Electric: $2/ft Woven: $6/ft	NRCS CA

OR	1993	typical	<u>System Type:</u> Access ramp: $600+fence ($100/yr maint) *(2006$: $788, $131/yr maint)* Nose/stream powered pump (surf/grndwtr): $350-$450/pump+fence ($50/yr maint) *(2006$: $460-$591, $66/yr maint)* Stream-powered pump w/flow&elev needs: $500-$1000/pump+fence ($50/yr maint) *(2006$: $657-$1314, $66/yr maint)* Plastic pipe (grndwtr): $1-$2/pipeline ft +troughs ($50/yr maint) *(2006$: $1.31-$2.63/ft, $66/yr maint)* Solar powered pump (grndwtr): $2K-$6K for solar equip, tank, fence, pad *(2006$: $2628-$7884)* Spring development (grndwtr): $700+fence+trough ($50/yr maint) *(2006$: $920, $66/yr maint)*	TSWCD, p6

Fence maintenance costs described in Table HR-2 range from $0.09 to $0.26/foot/year, depending on the fencing material. It should be noted that these estimates pertain to Iowa, not California.

Table HR-2. Fence Maintenance - $/foot

Location	Year	Units	Cost Per Unit	Source
Iowa	2005	1330'	<u>Fence Material:</u> Woven wire: $0.26/ft/yr Barbed wire: $0.21/ft/yr Hi-tensile, non-elec: $0.15/ft/yr Hi-tensile, elec: $0.09/ft/yr	MO-T6

Table HR-3 describes Evergreen's estimates of riparian planting cost, while Table HR-4 describes estimates from other data sources. Evergreen's estimates are $5K-135K/acre, and vary with the level of site preparation and material/site accessibility. The estimates used for CDFG's Coho Recovery Strategy (CDFG-04, p1.17) are $30K-60K/acre and were selected to fall within the range of Evergreen's estimates. Project costs reported in HT07a and HT07b are ~ $100K-$120K/acre (with the notable exception of a $434.8K/acre project). The NRCS estimates are at the low end of this range: ~$100-$1800/acre - depending on what is planted (trees or plants) and planting requirements (e.g., protected, shelters, wire cages, native species). An NRCS estimate of landing clearing costs is also included to address situations where clearing is a prerequisite for planting. The Bair example - $110/acre, pertaining to riparian reforestation - was also at the lower end of Evergreen's range .

For the examples from CDFG and Hampton, costs could be calculated on a per-mile but not a per-acre basis. Costs vary widely ($1K to > $200K/mile); some of this difference may be due to variations in the width of the buffer being planted (which is not clear from the data sources). Evergreen uses the following conversion from miles to acres (with acreage doubled when planting on both sides of the stream).
1 mile x 50 foot buffer = 6 acres (100% planted)
1 mile x 50 foot buffer = 1.8 acres (30% planted)
1 mile x 150 foot buffer = 18.2 acres (100% planted)
1 mile x 150 foot buffer = 5.5 acres (30% planted).

Table HR-3. Riparian Planting Projects - $/acre (Source: Evergreen 2003, p. 16)
Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management.

Materials/Site Accessibility	Level of Site Preparation		
	Flat/Light Clearing	Avg Slope/Avg Clearing	Steep/Heavy Clearing
Low Cost	$5K-25K	$20K-50K	$60K-100K
Medium Cost	$10K-35K	$45K-65K	$70K-120K
High Cost	$30K-50K	$55K-80K	$100K-135K

Table HR-4. Planting - $/acre, $/stream length For entries involving multiple projects, cost reported as mean or mean (range) as avail.				
Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	Distance from Road (assuming 50' buffer along streams): <0.25 mi: $30K/acre 0.25-0.5mi: $35K/acre 0.5-1mi: $45K/acre 1-2mi: $50K/acre 2-3mi: $55K/acre >3mi: $60K/acre	CDFG-04 p1.17
SONC SONC NOCECA NOCECA CentralVly SCACO	98-05 2003$	1 site(10ac) 2 sites(4mi) 4sites(128ac) 7 sites(3mi) 4sites(610ac) 1 site(28ac)	$1.8K/acre $30.8K ($8.8K-$52.9K)/mi $8K ($1.8K-$13.5K)/acre $95K ($3.7K-$436.6K)/mi $4.8K ($2K-$7.8K)/acre $23.6K ($495-$63.1K)/acre	HT07a-T61, pp121-125
CA	02-04	18 sites 14 sites 10 sites	Site Accessibility: Easy:$55.8K ($600-$434.8K)/acre (median=$8.9K/acre) Average: $9.1K ($40-$87.5K)/acre (median=$1.3K/acre) Difficult: $4K ($910-$15.1K)/acre (median=$2.3K/acre)	HT07b-T21, p 43.contrctr
CA	02-04	19 sites 11 sites	Prevailing Wages Required: No: $1.8K ($40-$8.5K)/acre Yes: $77.1K ($1.8K-$434.8K)/acre	HT07b-T30, p50,contrctr

CA	02-04	2 sites 8 sites 8 sites 22 sites	<u>Irrigation Type</u> Dri-water: $46.1K ($8.5K-$83.7K)/acre Drip irrig: $33.0K ($163-$120.5K)/acre Hand irrig: $26.2K ($414-$100K)/acre None: $27.1K ($40-$434.8K)/acre	HT07b-T34, p54,contrctr
CA farmland	FY07	typical	170-259 trees/acre: $109/acre 260-300 trees/acre: $154/acre 301-435 trees/acre: $182/acre 436-681 trees/acre: $240/acre 110 trees/acre (protected): $770/acre 300 trees/acre (protected: $2000/acre 170-260 trees/acre (shelters): $130/acre 261-325 trees/acre (shelters): $175/acre 326-434 trees/acre (shelters): $200/acre >435 trees/acre (shelters): $260/acre 95-150 plants/acre (wire cages):$225/acre 151-200 plnts/acre (wire cages):$320/acre 201-325 plnts/acre (wire cages):$470/acre 95-150 plants/acre (native spp): $735/acre 150-200 plnts/acre(native spp):$1050/acre 200-260 plnts/acre(native spp):$1380/acre 261-325 plnts/acre(native spp):$1755/acre Land clearing: $400/acre	NRCS CA
WindR-WA	2000	mile	$5K ($4K-$8K)/mi; $110/acre - riparian reforestation	Bair-p107
MaacamaCrk-SonomaCty	01-02	300'	$12,790 ($225K/mi) - willow walls	CDFG-186

KlamathR WilsonCrk ShastaR	02-03	2600' 1 mi 2 mi	$27.6K ($52.8K/mi) $18.1K/mi $109,934 ($55K/mi)	CDFG-170 CDFG-208 CDFG-296
GarciaR-MendcnoCnty LowerTerwer Crk-KlamathR-DelNorteCnty	03-04	1600' 1600'	$67,695 ($223K/mi) - bioengineer $39,671 ($131K/mi) - willows, native	CDFG-117 CDFG-223
Klamath ShastaR	04-05	1600' 7000'	$55,868 ($184K/mi) - willow/native trees/bioengineer/removal of exotics $79,573 ($60K/mi)	CDFG-122 CDFG-172
CA	2000	11 projects	$13.7K ($1.0K-$47.5K)/mi	Hampton-T3, p125
CA		12 projects	$8 ($0.17-$23)/ft or $42.2K ($898-$121K)/mi	Hampton-T4, p125

Some of the projects in Table HR-4 above included irrigation in combination with revegetation. Table HR-5 provides estimates of irrigation costs only (NRCS CA) that range from $800 to $3K/acre and vary by irrigation method and habitat type. An example of capital cost (irrigation pumps, CDFG-279) is also provided.

Table HR-5. Irrigation - $/acre, $/project

Location	Year	Units	Cost Per Unit	Source
CA farmland	FY07	typical	Irrig system, surf & subsurface: $3K/acre Micro-irrig, hillside: $1.5K/acre Micro-irrig, wildlife-upland habitat: $800/acre Sprinkler irrig, hillside/sloping: $2.5K/acre	NRCS CA
Eel R	04-05		$17.3K - solar powered irrigation pumps to ensure seedling survival until natural roots grow	CDFG-279

Information on invasive weed control is limited: $5K-$12K/acre for projects on the Napa and Smith Rivers (04-05 CDFG-072 & CDFG-077). NRCS cost estimates for farmland are much lower ($10-$375/acre) and vary, depending on eradication method (e.g., mechanical/chemical, mechanical/chemical/handtool), land type (e.g., upland, wetland), and vegetation type (e.g., woody, herbaceous). A Russian River project (02-03 CDFG-325) can be costed on a per-mile basis but cost per acre is not known.

Table HR-6. Invasive/Noxious Weed Control - $/acre, $/mile

Location	Year	Units	Cost Per Unit	Source
RussianR	02-03	2.5mi	$30.2K ($12.1K/mi,broom,native reveg)	CDFG-325
NapaR SmithR	04-05	22,865yd^2 (4.7acres) 10acres	$55.7K ($11.9K/acre, arundo erad) $49.5K($5K/acre,Eng ivy, plantseedlng)	CDFG-072 CDFG-077

CA farmland	FY07	typical	***Exotic Vegetation Management*** Woody veg, mech/chem/handtool Light: $18.75/acre Moderate: $37.50/acre Intensive: $75/acre Mechanical/chemical, upland Light: $10/acre Moderate: $20/acre Intensive: $50/acre Woody veg (early successional), mech/chem/handtool Intensive: $50/acre Herbaceous veg, early successional, mech/chem/handtool Moderate: $25/acre Mult applic/yr, wetland, mech/chem/ handtool Light: $75/acre Moderate: $187.5/acre Intensive: $375/acre ***Competing Vegetation Management*** Conservation cover General: $50/acre Riparian herbaceous: $50/acre Forest stand improvement Mastication: $920/acre Hand, 0-15%slope, 20-40%cover:$600/acre Hand, 15-30%slope, 40-60%cover:$900/acre Hand, 30-50%slope, 60-90%cover:$1200/acre Brush rake: $379/acre Chemical: $150/acre	NRCS CA

HS - BANK STABILIZATION

This section covers stabilization of eroding, collapsing or otherwise de-stabilized bank.s. Table HS-1 provides Evergreen's cost estimates for streambank stabilization, Table HS-2 provides similar estimates from other data sources, and Table HS-3 focuses on levee restoration.

Evergreen's estimates ($30-$1000/foot) vary by extent of excavation and waterway size. Cost estimates used in CDFG's Coho Recovery Strategy (CDFG'04, p1.19) were $250-$350/foot and fall within the range of Evergreen's estimates for small/medium waterways. Generally speaking, other project costs in Table HR-2 also fall within Evergreen's range of estimates.

The higher cost projects appear to involve stabilization work other than just revegetation and/or work on steep terrain (e.g.,03-04 CDFG-285, 04-05 CDFG-263). For those projects that are identifiable to location, costs also appear to be higher in urban areas - e.g., southern California (05-06 CDFG-065, 069, 097) and King County, WA (Neal-T2, p159 & Neal-T3, p161). By contrast, cost in the rural Wind River watershed ($9-$42/ft, Bair-p107) falls toward the low end of Evergreen's range.

Table HS-1. Streambank Improvements - $/lineal foot (Source: Evergreen 2003, p. 30)
Cost estimates pertain to Puget Sound. Estimates include construction, design, permitting, basic monitoring & routine maintenance (2 yrs), reestablishing site to prior conditions, project management.

Extent of Excavation	Size of Waterway		
	Small	Medium	Large
Minimal	$30-60	$60-150	$150-400
Moderate	$60-100	$150-250	$400-700
Substantial	$100-200	$250-500	$700-1000

Table HS-2. Bank Stabilization - $/foot

Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	Distance from Road: 0.25-0.5mi: $250/ft 0.5-1mi: $275/ft 1-2mi: $300/ft 2-3mi: $325/ft >3mi: $350/ft	CDFG'04, p1.19
GualalaR	01-02	3200'	$91,850 ($29/ft)	CDFG-196
NF MattoleR EelR BearR-HmbldtCnty	02-03	1500' 4915' 260'	$46,806 ($31/ft) $157.3K ($32/ft) $37,962 ($146/ft)	CDFG-096 CDFG-134 CDFG-181
StaRosaCrk-SonomaCnty	03-04	350' long x 30' high creekbank	$124,201 ($355/ft) - stabilize/ construct/revegetate)	CDFG-285

SalmonCrk RussianR VanDuzenR StaYnezR	04-05	150' 150' 1500' 520'	$15,187 ($101/ft) - bioengineer $18,774 ($125/ft) - bioengineer $75,065 ($50/ft) - boulder, bioengineer $296,692 ($571/ft) - stabilize/ construct/revegetate	CDFG-030 CDFG-069 CDFG-158 CDFG-263
VenturaR StaYnezR StaMonicaBy KlamathR EelR	05-06	300' 1600' 300' 950' 3080'	$62,571 ($209/ft) $264,605 (165/ft) $110,894 ($370/ft) $86,609 ($91/ft) $92,241 ($30/ft) - incl riparian tree planting	CDFG-065 CDFG-069 CDFG-097 CDFG-118 CDFG-279
SONC NOSECA/ SONC SCACO	98-05	1 site(0.2mi) 1 site(0.03mi) 1 site(2.0mi)	$163.9K/mi ($31/ft) $181.9K/mi ($34/ft) $510K/mi ($97/ft)	HT07a-T61, pp121-124
CA	98-05 2003$	3 projects	$54 ($31-$97)/ft	HT07b-T63, p 90,CHRPD
CA	02-04	 10 projects 25 projects 18 projects	<u>Material Complexity:</u> Minimal:$30 ($5-$59)/ft Moderate:$120 ($4-$750)/ft Substantial:$181 ($6-$895)/ft	HT07b-T69, p 96,contrctr
Sacrmnto/San JoaquinDelta	2002	3.72 mi	$1.5M ($76/ft) - bioengineering, planting/baffling	ERP-02-P12
WindR-WA	2000	typical	$9-$42/ft	Bair-p107
King County, WA	1995 1997	1400' 100'	$444K ($317/ft) - instream/ floodplain)* *(2006$: $560K/project, $400/ft)* $93K ($930/ft) - LWD/bank stabilization* *(2006$: $113K/project, $1133/ft)*	Neal-T2, p159 Neal-T3, p161
* Includes design, land/easements, permits, SEPA and construction. For 1995 project, replanting, irrigation and 5 year plant maintenance also included.				

Table HS-3 provides levee-related cost estimates for several Central Valley rivers, the Pajaro and San Lorenzo Rivers (in Santa Cruz/Monterey counties), and Green River (in Washington). Comparison of estimates from different time periods suggests that levee repair costs have increased significantly (beyond the rate of inflation) - perhaps reflecting major change in levee demand and/or input supply conditions in recent years.
<u>Central Valley:</u> A single example of levee evaluation costs was found ($11/foot; Harder 06, p21). Levee repair costs from the 1980s and early 1990s were ~$500-$1000/foot (after correcting for inflation). More recent cost estimates are ~$5K-$6K/foot. Although per-foot cost estimates were not available for the Yuba/Feather River project (EPS '06, Tables B1&B2), levee improvement: environmental mitigation cost ratios from that project (25:1 for the Yuba, 8:1 for the Feather) are provided here, as they may also be useful for recovery planning.
<u>Pajaro/San Lorenzo River:</u> The 1989 cost estimates were ~$200-$500/foot (after correcting for inflation). The more recent estimates (developed by USACOE to evaluate various alternatives for Pajaro River flood protection) are ~$1.5K to $5K/foot.
<u>Green River:</u> Suggests the wide range of costs possible for levee repair.

Table HS-3. Levee Evaluation/Repair/Setback/Habitat Enhancement ($/foot)

Location	Year	Units	Cost per Unit	Source
CentralValley	2006	typical	$60K/mi (11/ft) - structural re-evaluation	Harder 06, p.21
SacrR	2006	29 sites, 30K ft	$172.5M ($5750/ft) - emergency erosion repair	DWR 06
SacrR	1980s 2005	typical typical	$300/ft - repair *(2006$: $500/ft)* Up to $5K/ft - repair	DWR 05, p.5
Bear River	2007	10K ft	$51M ($5.1K/ft) - setback	GEI 07
Twitchell Island, SanJoaqR	early 90s	3K ft	$2.5M/mi ($473/ft) - setback *(2006$: $636/ft)* $3.5-$4M/mi ($663-$758/ft) - setback+planting *(2006$: $891-$1019/ft)*	Nuedeck 00
Yuba R Plain FeatherRPlain	2006		Levee improve$:envir mitigatn$ $40.5M:$1.6M=25:1 $191.6M/$23.4M=8:1	EPS 06, Tables B-1 & B-2
SanLorenzoR PajaroR	1989	5.2K ft 12K ft	$1.75M ($337/ft)-rebuild levee *(2006$: $499/ft)* $1.84M ($153/ft)-repair *(2006$: $226/ft)*	McDonnell '92

Pajaro River mainstem	2002	11.4mi* 60,192'	Alt 1-$145.8M ($2422/ft), floodwall/levee raise Alt 2-$175.4M (2914/ft), 100'setback Alt 3-$177.3M ($2946/ft), 100'-225' setback Alt 4-$322.2M ($5353/ft), floodwall	USACOE '02
Pajaro River tributaries (Salsipuedes &Corralitos Creeks)	2002	4.4mi* 23,232'	Alt T1-$35.1M ($1511/ft), levee raise Alt T2-$38.8M (1670/ft), setback Alt T3-$34.7M ($1494/ft), hybrid raise/setback	USACOE '02
Pajaro River mainstem (MS) & tributaries (T)	2003	15.8mi* 83,424'	Alts 2A&T4-$217.7M ($2610/ft), 100' setback Alts 3&T3-$218.3M ($2617/ft), 225' setback Alts 2A&T3-$215.3M ($2581/ft), 100' MS, 225' T Alts 3&T4-$220.7M ($2646/ft); 225' MS, 100' T	USACOE '03
* Info on project size obtained from MIG Inc (2001), p. 14. Mainstem includes river reaches 1-4; tributaries include river reaches 5-6.				
Green River, Seattle	2007	typical	$1K-$15K/ft, repair	Johnson 07

HU - WATERSHED RESTORATION (UPSLOPE)

This section covers upslope restoration to reduce stream sedimentation. Table HU-1 pertains to road decommissioning, Table HU-2 to road upgrade, Table HU-3 to landslide/gully stabilization and Table HU-4 to planting in upland areas (as distinct from riparian planting described in Table HR-4).

According to Weaver/Hagans (WH-T7, p100), road decommissioning costs generally range from $2K-$35K/mile but may go as high as $51K/mile for moderately difficult roads. Most of the other examples fall within Weaver/Hagans' range. CDFG's Coho Recovery Strategy (CDFG '04, p1.28) assumes $9K/mile, which is toward the lower end of the Weaver/Hagans' range.

Table HU-1. Road Decommissioning - $/mile				
Location	Year	Units	Cost Per Unit	Source
CA	2000	typical	Moderately difficult roads: $51K/mi Range of roads: $2K-$35K/mi	WH-T7, p100
CA	2004	typical	$9K/mi	CDFG'04 p1.28
KlamathR Mendcno Klamath	02-03	9 mi 3.5 mi 34.3 mi	$32,029 ($3.6K/mi) - timber road $105,025 ($30K/mi) $348,407 ($10.2K/mi) - forest road	CDFG-214 CDFG-233 CDFG-331
TrinityR NoyoR	03-04	3.6 mi 8.5 mi	$43,690 ($12.1K/mi) $137,495 ($16.2K/mi)	CDFG-197 CDFG-267
SalmonR KlamathR TrinityR	04-05	5.9 mi 4.5 mi 1.4 mi	$259,087 ($43.9K/mi) $257,787 ($57.3K/mi) $130,567 ($93.3K/mi)	CDFG-004 CDFG-006 CDFG-251
TrinityR VanDuzenR HumboldtBy HumboldtBy	05-06	5 mi 2.25 mi 3 mi 9.7 mi	$320,866 ($64.2K/mi) $188,560 ($83.8K/mi) $333,736 ($111.2K/mi) $411,567 ($42.4K/mi)	CDFG-015 CDFG-119 CDFG-120 CDFG-121
Klamath-FS TrinityR	06-07	13.3 mi 2.33 mi	$392,797 ($29.5K/mi) $25,000 ($10.7K/mi)	CDFG-169 CDFG-104
SONC	98-05 2003$	2 sites	$121.6K ($8.2K-$235K)/mi	HT07a-T61, p121
CA	02-04	39 sites	$34,090 ($4K-$200K)/mi	HT07b-T76, p101.contrctr
CA	98-05 2003$	3 sites	$285.2K ($164K-$510K)/mi	HT07b-T77, p102,CHRPD
WA- ForestSvc	2000	6 sites	$6,522 ($1,8K-$15K)/km, or $4.1K ($1.1K-$9.3K)/mi	Coffin-T1, p53

According to Weaver/Hagans (WH-T7, p100), road upgrade costs are generally $10K-$35K/mile but may go higher than $45K/mile for difficult or high-density sites. CDFG's Coho Recovery Strategy (CDFG '04, p1.27) assumes $15.9K/mile, which is toward the lower end of the Weaver/Hagans' range (~$23K/mile). Most of the other examples fall within Weaver/Hagans' range.

Table HU-2. Road Upgrade - $/mile				
Location	Year	Units	Cost Per Unit	Source
CA	2000	typical	Upgrade Type: Difficult, 100 yr design: $42.5K/mi Mod-diff, hi-site density: $45.5K/mi Watershed-wide, low/high priority, 100 yr design: $25K-$35K/mi Watershed-wide avg, 100 yr design: $10K-$35K/mi	WH-T7, p100
CA	2004	typical	$15.9K/mi	CDFG'04 p1.27
MendcnoCnty SiskiyouCnty	01-02	1.1 mi 17.6 mi	$32,963 ($30K/mi) $741,656 ($42.1K/mi)	CDFG-159 CDFG-165
KlamathR SalmonR SalmonR	02-03	22.2 mi 16.7 mi 16.7 mi	$558,016 ($25.1K/mi) $698,384 ($41.8K/mi) $492,376 ($29.5K/mi)	CDFG-017 CDFG-018 CDFG-019
SmithR MndocinoCnty	03-04	10.9 mi 6 mi	$509,363 ($46.7K/mi) $173.3 ($28.9K/mi)	CDFG-007 CDFG-037
EelR RussianR GarciaR EelR RussianR MattoleR	04-05	12.1 mi 11.7 mi 5.25 mi 23.1 mi 11 mi 2 mi	$176,718 ($14.6K/mi) $560,476 ($47.9K/mi) $155,382 ($29.6K/mi) $299,076 ($12.9K/mi) $427,212 ($38.8K/mi) $59,706 ($29.9K/mi)	CDFG-027 CDFG-111 CDFG-195 CDFG-225 CDFG-268 CDFG-285
EelR	06-07	8 mi	$389,486 ($48.7K/mi)	CDFG-009
CA	98-05 2003$	12 sites	$18K ($1.9K-$52K)/mi	HT07a-T60, p118

SONC NOCECA-SONC NOCECA	98-05 2003$	3 sites 2 sites 7 sites	$12.3K ($2.1K-$32.1K)/mi $12.7K ($3.3K-$22.1K)/mi $22K ($1.9K-$52K)/mi	HT07a-T61, p121
CA	02-04	43 sites	$169K ($1K-$3.5M)/mi	HT07b-T86, p123,contrctr

Limited information contained in Table HU-3 (mostly from the Eel River) shows landslide repair costs ~ $1K-$3.5K/site.

Table HU-3. Landslide and Gully Stabilization - $/acre				
Location	Year	Units	Cost Per Unit	Source
EelR EelR MarinCnty EelR	04-05	34 sites 54 sites 80 sites 30 sites	$115.9K ($3410/site) $86.5K ($1601/site) $279.8K ($3497/site) $29.7K ($990/site)	CDFG-156 CDFG-160 CDFG-174 CDFG-213

The estimate of <u>upland</u> planting cost in Table HU-4 falls toward the lower end of <u>riparian</u> planting costs previously described in Table HR-4; however, it is difficult to generalize from a single example.

Table HU-4. Planting - $/acre				
Location	Year	Units	Cost Per Unit	Source
TrinityCnty	02-03	100 acres	$194,468 ($1945/acre)	CDFG-254

TW - TAILWATER MANAGEMENT

Cost of tailwater management is represented in Table TW-1 in terms of acres of farmland irrigated by tailwater. Costs are ~$20-$400/acre. The NRCS example suggests that cost per acre declines as total acreage increases.

Table TW-1. Tailwater Management System - $/acre				
Location	Year	Units	Cost Per Unit	Source
SiskiyouCnty	01-02	540 ac	$220.2K ($408/acre, collect, hold and return water to high end of unit for re-use)	CDFG-049
CA	1987	typical	$125/acre *(2006$: $198/acre)*	USEPA p13
CA-rice	1990	typical	<u>System Type:</u> Static irrig system*:$95/acre (6-10 acre basin) *(2006$: $135/acre)* Recirculating system: $20/acre (1000 acre system) to $150/acre (80 acre system) *(2006$: $28-$214/acre)*	Hill 4/7 Hill 3/7
* Static irrigation consists of a ditch and flashgated pipe system that limit inflow into basin to amount required to replenish water lost to evapotranspiration and percolation. This recent innovation in rice irrigation eliminates possibility of tailwater spillage into public drains.				
CA	FY07	typical	***Size of Area Covered by System:*** 1-50 acres: $10K, $400/acre(=$10K/25ac) 51-100 acres: $20K, $267/acre 101-200 acres: $30K, $200/acre 201-300 acres: $40K, $160/acre 301-400 acres: $60K, $171/acre 401-500 acres: $80K, $178/acre	NRCS CA
CA-cotton	2000	typical	Furrow irrig+tailwater system: $60-$80/acre	Sanden
Colorado	1998	typical	$150-$225/acre (earthwork, pipeline install, pump assembly)	Broner

WC - WATER CONSERVATION MEASURES

This sections cpertains to methods of providing more efficient use of water extracted from stream systems. Table WC-1 pertains to ditch lining and Table WC-2 to piping.

Canal lining costs described in Table WC–1 are ~ $15-$96/foot. Such projects often involve installation of related equipment such as control structures. For large projects, the cost of planning/environmental/administrative aspects can comprise a substantial portion of total project costs (e.g., 62% of total costs for the ACID project). Project life ranges from 20-50 years. In cases where proponents provided estimates of project benefits (in terms of value of conserved water), benefits were estimated using water prices of $25-$75/acre foot.

Table WC-1. Ditch Lining - $/ditch length, $/acre farmland treated

Location	Year	Units	Cost Per Unit	Source
Anderson	01-03	2 mi	Cost Breakdown: Planning/environ/admin: ~$4M Control struc, measurement flumes, SCADA systems@13 sites: $1.494M ($114.9K/site) Concrete anal lining: $1M ($96/ft) Project life=30yrs Value conserved water=$50/af	ACID
MercedCnty	01-03	25K' 600 ac	$2M ($79/ft, $3.4K/acre) Includes 50 control structures Project life=50yrs Value conserved water=$25/af	MCWD
CA	FY07	typical	Liner Type: Plain concrete: $20/ft Flexible membrane: $15/ft Galvanized steel: $20/ft	NRCS CA
CA	01-03	13.5K’	$251K ($19/ft) - concrete Project life=20yrs Value conserved water=$75/af	OWID
CA	2001	8K’	$242K ($30/ft) - concrete Project life=20yrs	OWID ‘01

PlacerCnty	01-02	3 mi	Cost Breakdown: Planning/environ/admin: $81K 12 remote flow monitoring stns:$450K ($37.5K/stn) Canal lining: $794K ($50/ft) - concrete Project life=25 yrs Value conserved water=$40/af	PCWA

As indicated in Table WC-2, the only piping example found was $16/foot.

Table WC-2. Piping - $/pipe length				
Location	Year	Units	Cost Per Unit	Source
CA farmland	FY07	typical	$16/ft - irrig water conveyance, aluminum pipeline	NRCS CA

WD - WATER MEASURING DEVICES

This section pertains to instream and water diversion measuring devices to track mainstem/tributary flows. Table HB-4 above provides cost estimates for instream projects that involve use of head gates with other devices. Table WD-1 pertains to head gates alone. The limited examples provided indicate head gate costs of $2.8K-$10K.

Table WD-1. Head Gate - $/project				
Location	Year	Units	Cost Per Unit	Source
SiskiyouCnty	01-02	123 diversions	$350K ($2.8K/diversion) - lockable head gate & flow measuring device	CDFG-056
ScottR-Klamath	06-07	14 diversions	$142K ($10.1K/diversion) - head gate & flow measuring device	K033
CA farmland	FY07	typical	Headgate <3cfs: $5K Headgate >3cfs: $10K	NRCS CA

WP - WATER PURCHASE/LEASE

Table WP-1 pertains to purchase/lease/acquisition of short- or long-term water rights to improve water quality and/or quantity. The DWR sources indicate Central Valley water transfer prices of $43 - $246/acre foot/year. CDFG's Coho Recovery Strategy (CDFG'04, p1.43) assumes $100/af/yr - a value within the range of the DWR data. The water prices in Table WC-2 (previously presented in section "WC-Water Conservation Measures") are considerably higher than the prices imputed to water conserved in estimating value of water conserved by ditch lining in Table WC-2. A major distinction between the two is that Table WC-2 pertains to conserved water valued at the existing price being paid by the water user, while the Table WP-1 prices are transfer prices.

Table WP-1. Purchase/Lease of Water Right - $/acre foot (af)

Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	$100/af/yr	CDFG'04 p1.43
Central Valley	01-02		***Upstream of Delta***	DWR
		135K af	State-YubaCntyWater Agency: $10.1M ($75/af/yr)	
		7.1K af	Fed-SacmntoGrndwtrAgency: $535.7K ($75/af/yr)	
			South of Delta	
		36.8K af	State-KernCntyWtrAgency: $6.7M ($181/af/yr)	
		60.6K af	Fed-KernCntyWaterAgency: $11M ($181/af/yr)	
Central Valley	02-03		***Upstream of Delta***	DWR
		4.9K af	State-OrovilleWyandotteIrrigDist: $386.6K ($75/af/yr)	
		65K af	State-YubaCntyWaterAgency: $5.5M ($85/af/yr)	
			South of Delta	
		125K af	State-KernCntyWaterAgency: $21.3M ($170/af/yr)	
		20K af	Fed-StaClaraVlyWaterDist: $3.2M ($162/af/yr)	
Central Valley	03-04		***Upstream of Delta***	DWR
		100K af	State-YubaCntyWaterAgency: $8.8M ($88/af/yr)	
		20K af	State-PlacerCntyWaterAgency: $1.7M ($83/af/yr)	
			South of Delta	
		35K af	State-KernCntyWaterAgency: $8.6M ($246/af/yr)	

Central Valley	04-05	4.6K af 89.7K af 8.8K af	***Upstream of Delta*** State-YubaCntyWaterAgency: $200K ($43/af/yr) ***South of Delta*** State-KernCntyWaterAgency: $15.8M ($177/af/yr) State-StaClaraVlyWaterDist: $1.6M ($184/af/yr)	DWR

HA - HABITAT ACQUISITIONS/LEASES/CONSERVATION EASEMENTS ($/ACRE)

Tables HA-1 and HA-2 respectively describe Evergreen's cost estimates for undevelopable land and parcels with medium-high development potential. Table HA-3 describes costs of easements and land purchases administered by California's Wildlife Conservation Board (WCB). Tables HA-4 and HA-5 respectively describe land acquisition and easement costs from a variety of other sources. Evergreen's estimates are inclusive of transaction and management costs as well as land acquisition price, while WCB's estimates include only acquisition price. The other data sources likely also include only acquisition price.

Evergreen's prices are $700-$4800/acre for undevelopable land (Table HA-1. For parcels with medium/high development potential and low to high amenity value, prices are $5K-$300K/acre for rural residential land, $60K-$600K/acre for suburban residential land, and $300K-$1.2M/acre for urban land; prices of parcels with very high amenity value are unpredictable (Table HA-2).

Table HA-1. Cost of Undevelopable Land - $/acre (Source: Evergreen 2003, p. 7)
Cost estimates pertain to Puget Sound. Estimates include appraisal, closing, commission, surveying, legal, project management costs.

Proximity to Urban Area	Zoning	
	Forest	Agricultural
Far 41+ mi	$700-1800	$1800-2400
Medium 21-40 mi	$1800-2400	$2400-3600
Near 0-20 mi	$2400-4800	$3600-4800

Table HA-2. Cost of Parcels with Medium-High Development Potential - $/acre (Source: Evergreen 2003, p. 6) Cost estimates pertain to Puget Sound. Estimates include appraisal, closing, commission, surveying, legal, project management costs.				
Zoning	Amenity Value			
	Low	Medium	High	Very High
Rural Residential	$5K-35K	$24K-60K	$60K-300K	$300K-1.2M
Suburban Residtl	$60K-120K	$120K-240K	$300K-600K	Unpredictable
Urban	$300K-600K	$600K-1.2M	Unpredictable	Unpredictable

The prices in Table HA-3 were derived by dividing WCB's expenditures for purchase/easement in each county by the number of acres subject to purchase/easement. These derived prices are $42 -$104.7K/acre for easements, and $267-$45.5K/acre for acquisitions. The acquisition prices are on the low side relative to Evergreen's estimates of $5K-$300K/acre for rural land and $300K-$1.2M/acre for urban land, (Table HA-2) and likely underestimate actual costs, as WCB's wildlife habitat acquisitions are often done on a cost-share basis.

Table HA-3. WCB Actions in 2000-2004: Total Acreage and $/Acre, by County (Source: Wildlife Conservation Board, 2005)				
	Conservation Easement		Fee Title	
County	Acres	$/Acre	Acres	$/Acre
Alameda			16,500	$4,485
Alpine				
Butte	10,369	$866	4,557	$726
Calaveras	3,669	$395		
Colusa	13,131	$128		
Contra Costa			3,808	$843
Del Norte			25,675	$812
El Dorado	1,178	$501	1,295	$4,239
Fresno			1,310	$7,291

Glenn			24,158	$568
Humboldt	3,640	$253	5,905	$5,184
Imperial				
Inyo			218	$4,394
Kern			4,743	$1,093
Lake			269	$968
Lassen			278	$1,079
Los Angeles			4,178	$43,083
Madera	443.5	$1636	1,140	$15,380
Marin			737	$7,017
Mariposa	6,801	$487		
Mendocino	560	$6607	39,704	$267
Merced	15,620.9	$893	4,359	$818
Modoc			2,080	$640
Mono	6,350	$506		
Monterey	27,715	$241	14,598	$1,408
Napa	17	$104,706	12,817	$546
Nevada			494	$1,387
Orange			6,508	$12,782
Placer			155	$1,131
Plumas	21,137	$140	279	$1,935
Riverside	1,324	$591	60,926	$1,871
Sacramento	5,526	$577	4,819	$1,159
San Bernardino			572	$6,324
San Diego			54,871	$2,135
San Francisco				
San Joaquin	3,515	$545		

San Luis Obispo	82,106	$420	32,551	$1,045
San Mateo	1,000	0	6,020	$2,495
Santa Barbara	1,406	$2,156	948	$15,651
Santa Clara			5,205	$1,822
Santa Cruz	18	$167	464	$12,349
Shasta	3,784	$158	1,524	$2,949
Sierra	500	$620	2,147	$12,809
Siskiyou	2,479	$42	118	$1,102
Solano	535	$1,903	5,536	$701
Sonoma	165	$10,333	5,484	$2,279
Stanislaus				
Sutter				
Tehama	21,557	$116	8	$44,063
Tulare	722	$176	2,667	$413
Tuolumne			333	$302
Ventura			3,018	$45,518
Yolo	6,983	$351	21,106	$865
Yuba	2,115	$56	2,153	$2,152
Total				

Tables HA-4 and HA-5 include information on habitat type, when available. Several projects involved expenditures on both acquisition and easement where it was not possible to determine how much was spent on each. Such projects were placed in Table HA-4 if most of the acreage involved acquisition and in Table HA-5 if most of the acreage involved easement; cost per acre was estimated by dividing total cost by total acreage (acquisition + easement).

Land acquisition values used by NMFS for the Columbia River Estuary Recovery Plan were $5K/acre for rural land and $100K/acre for urban land (Table HA-4, NOAA p5-46). These values are as low or lower than Evergreen's lowest prices for rural and urban land ($5K/acre and $300K/acre respectively, Table HA-2). For most other acquisitions described in Table HA-4, prices are ~ $200-$20K/acre, with the notable exception of several multi-million-dollar-per-

acre purchases in north/central California and southern California - both highly urbanized areas (Table HA-4: HT07a-T61, p121, NOCECA and SCACO). Prices of conservation easements (Table HA-5) are ~$300-$5.7K/acre - with the notable exception of a $65K/acre easement in Santa Barbara (CntySBPublicWrks).

Table HA-4. Land Acquisition - $/acre				
Location	Year	Units	Cost Per Unit	Source
ColR	2006	typical	Rural: $5K/acre Urban: $100K/acre	NOAA, p5-46
Mill/RockCrks-SmithR-DelNorteCnty	01-02	24,580 ac	$5M ($203/acre)	CDFG-034
SLOCreek	02-03	80 acres	$100K ($1250/acre)	CDFG-218
SONC SONC-NOCECA NOCECA CentralValley SCACO	98-05 2003$	16 sites 16 sites 51 sites 67 sites 87 sites	$12.1K ($157-$37.3K)/acre $10K ($316-$53.7K)/acre $295.6K ($138-$1.8M)/acre $5.9K ($195-$32.6K)/acre $87.3K ($387-$1.7M)/acre	HT07a-T61, p121
SanFranBay	1999	typical	$6K-$15K/acre (South Bay) $2K-3K/acre (North Bay)	USEPA ’99, p171
Badger Creek (Cosumnes River)	1996	4300 acres	$12.0M ($2.8K/acre) - wetland/ forest/vernal pool, Valensin Ranch	ERP-96-M06
Cache Slough (SacrmntoR/ SanJoaquinDelta)	1997	4760 acres	$8.747M ($1.8K/acre) - tidal wetland/ riparian corridor/upland, Liberty Island	ERP-97-B03
San Joaquin River	1997	6288 acres	$20.5M ($3.3K/acre) -floodplain, USFWS SanJoaq Natl Wildlife Refuge 4324 acr fee, 1964 acr easement	ERP-97-B04
Sacramento River	1997	1880 acres	$8.705M ($4.6K/acre) - seasonal wetland/riparian/riverine/aquatic	ERP-97-N02
Sacramento River	1997	95 acres	$838.7K ($8.9K/acre)	ERP-97-N04
Butte Creek	1997	93 acres	$151K ($1.6K/acre) - partial funding only	ERP-97-N06

Cosumnes River	1997	1655 acres	$5.210M ($3.1K/acre) - agricultural/dairy/woodland/ grassland/seasonal wetlands, incl cleanup/repair	ERP–97-N14
Napa River	1998	68 acres	$910K ($13.4K/acre) - marsh wetland, incl restoration	ERP-98-B13
Merced River, Tuolumne River	1998	360 acres	$830.5K ($2.3K/acre) -riparian/ wetland/riverine, Basso Bridge Ecological Reserve & Merced River ranch land	ERP-98-CO4/CO5
Butte Creek	1998	93 acres	$160.4K ($1.7K/acre) - riparian/ wet meadow/grassland/woodland	ERP-98-F03
Sacramento River	1998	537 acres	$2.123M ($4.0/acre) - aquatic/ wetland/riparian, Stones Lake NWR	ERP-98-F12
Petaluma River	1998	181 acres	$255K ($1.4K/acre) - Petaluma Marsh	ERP-98-F13
San Joaquin River	1998	224 acres	$1.1M ($4.9K/acre) - riparian wetland, San Joaquin NWR	ERP-98-F21
Napa River Marsh	1998	453 acres	$1.976M ($4.4K/acre) - South Napa R Tidal Slough	ERP-98-F23
Cosumnes River	1999	1512 acres	$5.2M ($3.4K/acre) - farmland/ riparian, McCormack-Williamson Tract	ERP-99-F04
Tuolumne River	2000	303 acres	$1.386M ($4.6K/acre) - Bobcat Flat Floodplain Acquis	ERP-00-F01
Cosumnes/ Mokelumne Rivers	2001	771 acres	$2.843M + $12.1K project mgmt ($3.7K/acre) - agricultural/ seasonalwetlands/upland/vineyard	ERP-01-N10
Stanislaus River	2001	371 acres	$2.613M ($7K/acre) - riparian/ agricultural land	ERP-01-N11
Sacrmnto/San Joaquin Delta	2001	9269 acres	$12.659M + $87.5K program mgmt ($1.4K/acre) -agricultural/ marsh/riparian/riverine land, Staten Island	ERP-01-N23

Sacrmnto/San Joaquin Delta	2002	1166 acres	$23M ($19.7K/acre) - wetland/ upland, Dutch Slough	ERP-02-C07-D
Tuolumne River	2002	198 acres	$706.6K($3.6K/acre) - floodplain/ riparian habitat, Big Bend 66 acres fee, 132 acres easement	ERP-02-D01
Stanislaus River	2002	184 acres	$2.4M + $357K project mgmt & admin ($13.2K/acre)	ERP-02D-C11
PetalumaRivDelta, SanPabloBay	2002	631 acres	$2.0M ($3.2K/acre) - tidal wetland/adjacent upland, Bahia site	ERP-02-P14
BigChicoCreek/ MudCreek/ SacrmntoRiver	2002	146 acres	$2.278M + $59.5K project mgmt & admin ($15.6K/acre) - irrigated cropland	ERP-02-P16-D
Crevis Creek (Deer Creek, Cosumnes River)	2002	294 acres	$823.2K ($2.8K/acre)	ERP-02-P49

Table HA-5. Conservation Easement - $/acre

Location	Year	Units	Cost Per Unit	Source
CA	03-04	typical	$209-$730/acre - rangeland	Anon'06,p4
Wolverton Gulch-Van DuzenR-HmboldtCnty	04-05	48 acres	$30K ($625/acre)	CDFG-128
ArroyoSeco R-MntereyCnty		100 acres	$300K ($3K/acre)	CDFG-259
SouthCoast StaBarbCnty	07-12	5 acres	$3.525M ($65K/acre)	CntySB PublicWrks
San Joaquin River	2001	362 acres	$2.075M ($5.7K/acre) - riparian/seasonal wetland	ERP-01-N08
Battle Creek	2001	2499 acres	$851.6K ($341/acre)	ERP-01-N24

NorthFork Cosumnes R	2002	2162 acres	$2.0M ($925/acre) - riparian/upslope 1814 acres easement, 348 acres fee	ERP-02-P02
Mill Creek/ Deer Creek	2002	23,846 acres	$4.470K ($187/acre - agricultural land	ERP-02-P26
Tuolumne River	1998	140 acres	$687.0K ($4.9K/acre) - permanent easement, Grayson Riv Ranch	ERP-98-F07
San Joaquin River Delta	1998	168 acres	$425K ($2.5K/acre) - permanent easement, Fern Headreach Island complex	ERP-98-F16
Deer Crk/Mill Crk - Sacr R	1998	166 acres	$688K ($4.2K/acre) - orchards/row crop agriculture/lowlands	ERP-98-F20
Sacrmnto River	1999	1512 acres	$2.0M ($1.3K/acre) - riparian/riverine	ERP-99-B12
LwrTuolumne /San Joaquin	1999	1073 acres	$1.4M ($1.3K/acre) - floodplain	ERP-99-R01
Battle Creek	1999	6851 acres	$2.048M ($299/acre) - 3 ranches, woodland/riparian/grassland/chaparral	IMM-02-I01

MD - MONITORING STATUS AND TRENDS (includes monitoring of baseline, status and trends in habitat, watershed processes and/or populations)

Table MD-1 includes monitoring projects funded by CDFG's Fisheries Restoration Grants Program over the past three fiscal years. Information on the nature of monitoring is provided, as available. Most of the projects focus on life history, migration, distribution, and abundance of particular species on particular streams. Costs are ~$12K-$300K/project. Most of the >$200K projects (e.g., 04-05 CDFG-054, CDFG-208, CDFG-260, CDFG-261; 05-06 CDFG-158 and CDFG-159) appear to have a strong analytical as well as monitoring component.

Table MD-1. Physical/Project-Scale Monitoring - $/project			
Location	Year	Cost Per Unit	Source
TopangaCrk	04-05	$98.3K-relate rainfall to recruitment/survival	CDFG-009
StaMonicaBay		$152.9K-steelhead abund/distribution	CDFG-010
MillCrk		$156.9K-life history, pop size	CDFG-012
SproulCrk(EelR)		$45.9K-production, run timing & size	CDFG-040
HumboldtBay		$216.2K-estuary use/residence time	CDFG-048
UpprRedwdCrk		$65.1K-juvenile migration, biometric data	CDFG-051
LowrRedwdCrk		$62.3K-juvenile migration, biometric data	CDFG-052
MendocnoCnty		$281.2K-life history in 6 streams, eval potential biases in spawning surveys	CDFG-054
ScottCrk		$192K-life history, support artificial propag programs to maintain ESA-listed pops	CDFG-153
SoCenCA		$82.4K-baseline data on spawning/rearing habitat conditions in 8 watersheds	CDFG-196
ScottR		$67K-data on watershed condition/stock status	CDFG-200
ScottR		$77.8K-outmigrant trapping	CDFG-202
ScottR		$45.9K-streamflow/precip gauging for Water Balance Model	CDFG-205
PrairieCrk-Hmbldt		$211.2K-validate monitoring protocols for watershed restoration	CDFG-208
Scott/ShastaR		$169.4K-juvenile migration	CDFG-224
DelNorte/Hmbldt		$307.1K-juvenile sal abundance for 2 regional watersheds, validate effectiveness of juvenile abundance trends as indic of adult pop conds	CDFG-260
SLO		$238.3K-distribution/habitat use; quantify linkages among stream physical habitat, water quality, macroinverts, land use & fish	CDFG-261
CanoeCrk-Hmbldt		$65.8K-effect of wildfire on habitat & aquatic ecosystem processes	CDFG-071

Mattole Eel/Salinas,SLrnzo McGarveyCrk(Kla mathRiver) MendocnoCnty FreshwaterCrk UpperRdwoodCrk LowerRdwoodCrk TomalesBay Scott/ShastaR MatilijaCrk	05-06	$11.5K-life stage monitoring, smolt prod est $78.2K-historical baseline for genetic monitoring $141.9K-life history, pop status $183.8K-life history 3 streams, evaluate potential biases in spawning surveys $264.8K-life history, eval potential biases in spawning surveys $48K-estimate smolt pop using mark-recapture $53.9K-estimate smolt pop using mark-recapture $149.5K-life history $170.4K-juvenile migration $140K-steelhead assessment	CDFG-082 CDFG-089 CDFG-116 CDFG-158 CDFG-159 CDFG-164 CDFG-166 CDFG-245 CDFG-252 CDFG-277
MattoleR MattoleR UpprRedwoodCrk LowrRedwoodCrk Scott/ShastaR MattoleR HumboldtBay TopangaCyn VenturaR	06-07	$15.6K-downstream migrant monitoring, abundance estimate for chinoook/coho $17K-smolt production monitoring $48.4K-smolt abundance estimation $54.4K-smolt abundance estimation $170K-juvenile emigration monitoring $30K-escapement monitoring $168K-estuary use/residence time by juv sal $55.3K-steelhead distribution/abundance $76.6K-juvenile stlhead distribution/abundance	CDFG-207 CDFG-208 CDFG-064 CDFG-066 CDFG-127 CDFG-204 CDFG-062 CDFG-027 CDFG-034

MO - MONITORING WATERSHED RESTORATION

Table MO-1 pertains to implementation monitoring to determine if project treatments were constructed correctly and as planned, effectiveness monitoring to determine if restoration has produced desired habitat conditions and/or watershed processes, validation monitoring to determine if hypothesized responses of habitat, watershed processes and/or populations to restoration were correct.

The descriptions in Table MO-1 pertain to the type of restoration activity being monitored, with the cost estimates pertaining only to the monitoring component. The highest cost ($221.7K, ERP-97-N13) was for a bank stabilization project involving large-scale monitoring of many variables. Costs associated with monitoring of other individual projects ranged from $7K (for revegetation project ERP-97-N08) to $90K (for fish screen evaluation project ERP-97-C02). Several other estimates ($87.4K for 04-05 CDFG-036, $142K for 05-06 CDFG-171) involved monitoring of multiple projects funded by CDFG's Fisheries Restoration Grants Program.

Table MO-1. Implementation, Efectiveness and Validation Monitoring - $/project			
Location	Year	Cost Per Unit	Source
CA CanoeCrk-Hmbldt ShastaR Mattole	04-05	$87.4K - monitor pending/completed Fisheries Restoration Grants projects $65.8K - effect of wildfire on habitat&aquatic ecosystem processes $61.4K - monitor restoration sites for project effectiveness (habitat and fish) $65.1K - evaluate effectiveness of watershed rehab project	CDFG-036 CDFG-071 CDFG-273 CDFG-284
CA	05-06	$142K-monitor pending/completed Fisheries Restoration Grants projects	CDFG-171
Sacramento River	1997	$90K-screen evaluation project at Princeton Pumping Plant Fish Screen Facility	ERP-97-C02
Tuolumne River	1997	$47.6K - spawning gravel introduction (11K tons)	ERP-97-C11
Sacramento River	1997	$34K - restoration of 200 acres agricultural land to native riparian forest	ERP-97-N03a
Sacramento River	1997	$102.5K - restoration of 93 acres agricultural land to native riparian forest	ERP-97-N03b
Mill Creek/ Sacramento River	1997	$7.0K - restoration of native riparian vegetation for anadromous fish	ERP-97-N08
Barker/Lindsay/ Cache Sloughs-Sacr/SanJoaqDelta	1997	$29.8K - vegetative restoration	ERP-97-N10
Barker/Lindsay/ Cache Sloughs-Sacr/SanJoaqDelta	1997	$48.7K - exotic species removal	ERP-97-N10
Georgiana Slough/ NoMokelumne R-Sacr/SanJoaqDelta	1997	$221.7K - evaluation of alternative vegetative/ biotechnical techniques for stabilizing bank erosion/restoring levees	ERP-97-N13
Tolay Creek-San Pablo Bay	1997	$60K - 435 acre wetland restoration	ERP-97-N19

Prospect Island/ Cache Slough-SacramentoRiver	1998	$2.353M - levee repair and pump out; large scale monitoring of fish/wildlife/water quality/ phytoplankton/zooplankton/vegetation/benthic/ bathymetry/organic carbon	ERP-98-A01
SacramentoRiver	1998	$49K - fish screen construction	ERP-98-B26
Sacramento River	2000	$10.8K - fish screen installation on intake structure at Pump Station #1	ERP-00-B01
SanJoaquinRiver	2001	$233.4K - riparian/wetland restoration	ERP-01-N08
Sacramento River	2001	$86.3 ($8.6K/screen) 10 vertical screens <40 cfs	ERP-01-N52
Tuolumne River	2002	$203K - riparian floodplain/riverine habitat	ERP-02-P19-D
Mokelumne River	2002	$224.9K - songbird response to riparian restoration	ERP-02-P20

PL - WATERSHED EVALUATION, ASSESSMENT AND PLANNING

Table PL-1 provides examples of watershed evaluations/assessments, including partial assessments such as road erosion surveys and stream surveys. Almost all of the examples in the table come from CDFG's Fisheries Restoration GrantsProgram. Information on the nature of the assessment is provided, as available. Included are road inventory/sediment assessments (costed at $/mile), stream crossing assessments (costed at $/crossing), and watershed/estuary plans (costed at $/acre). According to Weaver/Hagans (WH-p91), the Grants Program allows up to $1.2K/mile for road assessments; just about all the road assessment examples in Table PL-1 meet this criterion. Stream crossing assessments cost $650-$1365/crossing. Most of the watershed plans cost $8-$13/acre and appeared to pertain mostly to erosion control. Several exceptions include a project on the Klamath River to address riparian/channel problems ($76/acre, 05-06 CDFG-115) and two projects involving Humboldt Bay ($853 and $3157/acre, 02-03 CDFG-169 & 227). CDFG's Coho Recovery Strategy (CDFG'04, p1.34) uses a planning cost estimate that is not scaled to the size of the plan ($200K/ planning exercise).

Table PL-1. Watershed Evaluation, Assessment and Planning - $/acre, $/mile, $/crossing				
Location	Year	Units	Cost Per Unit	Source
CA	2000	mile	$1.2K (max allowed by CDFG FRGP for full inventory/assessment/erosion control plan for roads)	WH-p91
HumboldtCnty DelNorteCnty EelR HumboldtCnty HumboldtCnty	01-02	6063 ac 8718 ac 45 mi 7 mi 10.3 mi	$48,080 ($8/acre) - erosion/hab rest $83,959 ($10/acre) - erosion/hab rest $20,338 ($452/mi) - road inventory $2011 ($287/mi) - road inventory $11,387 ($1106/mi) - road inventory	CDFG-106 CDFG-107 CDFG-136 CDFG-140 CDFG-141
RussianR EelR EelR EelR HumboldtBay HumboldtCnty SanFranCnty StaCruz Dnorte/Humb/ MendoCnties	02-03	20 mi 100 mi 8 mi 9 mi 35 acres 76.9 acres 66 mi 153 mi 65 stream crossings	$16.1K ($805/mi) - road inventory $60K ($600/mi) - sediment assess $2.7K ($333/mi) $3.0K ($329/mi) $29.9K ($853/acre) - estuary rehab plan $242,785 ($3157/acre) - erosion/hab rest $70,786 ($1072/mi) $142,812 ($933/mi) - erosion $42,246 ($650/crossing)	CDFG-046 CDFG-077 CDFG-106 CDFG-125 CDFG-169 CDFG-227 CDFG-279 CDFG-332 CDFG-327
EelR	03-04	50 mi	$38.1K ($763/mi) - sediment assess	CDFG-266
SalmonCrk MattoleR GualalaR MendocinoCty SLO Cty EelR MadR SmithR NavarroR	04-05	50 mi 40 mi 22 mi 140 mi 130 mi 110 mi 49.1 sqmi (31424 ac) 6.7 sqmi (4288 ac) 22 mi	$48,621 ($972/mi) - road inventory $23,128 ($578/mi) - road inventory $16,756 ($762/mi) - road inventory $145,175 ($1037/mi) - sediment assess $124,269 $956/mi) - sediment assess $131,023 ($1191/mi) - sediment assess $329,810 ($11/acre) $55,828 ($13/acre) $22,771 ($1035/mi, sediment assess	CDFG-047 CDFG-062 CDFG-112 CDFG-197 CDFG-210 CDFG-238 CDFG-255 CDFG-256 CDFG-271

CottonevaCrk MendcnoCnty MendcnoCnty MontereyCnty KlamathR MendcnoCnty HumboldtBay	05-06	110 mi 165 mi 80 crossng 14 mi 383 acres 50 mi 1.75 mi	$107,637 ($979/mi) - sediment assess $163,001 ($988/mi) - sediment assess $64.4K ($805/crossing) -inventory/assess $23,549 ($1682/mi) - sediment assess $29,240 ($76/acre) - ripar/chnnel dysfunc $55,514 ($1110/mi) $47,338 ($27.1K/mi) - estuary rehab	CDFG-040 CDFG-078 CDFG-101 CDFG-109 CDFG-115 CDFG-130 CDFG-276
RussianR Eel-SmithR	06-07	10 mi 50 crossng	$15,606 ($1560/mi) - sediment assess $68.2K ($1364/crossing)	CDFG-051 CDFG-084
CA	2004	typical	$200K/planning exercise	CDFG'04 p1.34

WATERSHED ORGANIZATION SUPPORT AND ASSISTANCE (OR)

Table OR-1 includes organizational support projects funded by CDFG's Fisheries Restoration Grant Program during the three most recent fiscal years. These can be roughly divided into two categories:
(1) database maintenance, costed at $135K-$152K/project/year. Data requiring maintenance include the California Habitat Restoration Project Database (CHRPD)(04-05 CDFG-033 & 05-06 CDFG-023), passage assessment data (04-05 CDFG-039 & 05-06 CDFG -031), and stream inventory reports (05-06 CDFG-033);
(2) watershed coordination/outreach, costed at $24K-$259K/project . The low end of this range range ($24K, 04-05 CDFG-219) pertains to support of a part-time watershed coordinator, while the high end ($259.1K, 05-06 CDFG-076) pertains to organizational work by a southern California non-profit. CDFG's Coho Recovery Strategy assumes $60K per educational/ technical assistance program (CDFG'04, p.1.35).

Table OR-1. Organizational Support and Assistance - $/project

Location	Year	Units	Cost Per Unit	Source
CA CA SmithR HumboldtCnty LindsayCrk ShastaValley	04-05	1 project 1 project 1 project 1 project 1 project 1 project	$134.3K - maintenance of CHRPD $196.7K - passage assessment database $52.0K - watershed coordinator $95.9K - RCD org support to landowners $24.1K - parttime watershed coordinator $137.3K - RCD outreach coordinator	CDFG-033 CDFG-039 CDFG-120 CDFG-211 CDFG-219 CDFG-230

CA CA CA StaBarb/ Ventura SmithR SalmonR AptosCrk to ORborder	05-06	1 project 1 project 1 project 1 project 1 project 1 project 1 project 1 project	$151K - maintain CHRPD $116.9K - passage assessment database $151.5K - consolidate stream inventory reports into CalFish $259.1K - organizational support by Community Environmental Council $103.8K - WatershedCoordinator $54.2K - org support by Restoration Council $141.3K - develop sampling frame for salmon monitoring	CDFG-023 CDFG-031 CDFG-033 CDFG-076 CDFG-098 CDFG-256 CDFG-268
CA	2004	typical	$60K per education/tech assist program	CDFG'04 p1.35

PM - PROJECT MAINTENANCE FOLLOWING PROJECT IMPLEMENTATION

Weaver/Hagans suggest $275/mile/year for culvert maintenance. Dupont estimates culvert life of 10-30 years, although his estimates pertain to Idaho (not California).

Table PM-1. Culvert maintenance - $/culvert/year

Location	Year	Units	Cost Per Unit	Source
CA	2004	typical	Routine culvert replacement/cleaning/fill slope excavation: $275/mile/year	WH, p101
Idaho	2004	typical	<u>Culvert Type:</u> Iron fish ladder - $10/yr (30 yrs) Block fish ladder - $10/yr (10 yrs) Baffled culvert - $20/yr (30 yrs) Drop structure - $40/yr (30 yrs)	Dupont-T5 (p62), T6 (p63)

Maintenance of 50 screens on Scott River cost $1.4K/screen/year. These are probably fairly small screens. Maintenance costs may be higher for larger screens.

Table PM-2. Fish Screen Maintenance - $/screen/year

Location	Year	Units	Cost Per Unit	Source
ScottR	01-02	50 screens	$68,896 ($1378/screen/year)	CDFG-034

Weaver/Hagans suggest $25/mile/year for maintenance of forest roads. Estimates for other types of roads could not be found.

Table PM-3. Road Maintenance - $/mile/year				
Location	Year	Units	Cost Per Unit	Source
CA	2000	typical	Maintenance inspection forest roads: $25/mi/yr	WH, p101

The only plant thinning example found was specific to farmland. Costs were contingent on the method of thinning (mechanical, hand, chemical).

Table PM-4. Upslope/Riparian Plant Thinnings - $/project				
Location	Year	Units	Cost Per Unit	Source
CA farmland	FY07	typical	Forest Stand Improvement-Thinning Mechanical: $850/acre Hand,15-30%slope,40-60%cover: $900/acre Hand,30-50%slope,60-90%cover: $1200/acre Chemical: $150/acre	NRCS CA

RE - COOPERATIVE FISH REARING

Flagg and Nash (1999) make a number of recommendations regarding operation of conservation hatcheries - e.g., select broodstock using appropriate genetic protocols, maintain broodstock on natural photoperiod and water temperatures, provide incubation and rearing environments that mimic conditions in the wild (e.g., overhead cover, instream structures/substrates), reduce rearing densities, vary water-flow velocities, provide "natural" diet composition and feeding rates, provide bottom feed delivery systems, rear fish in water from the intended return location, release hatchery smolts at sizes similar to wild smolts, provide for volitional releases that do not exceed carrying capacity, have multiple broodstock facilities to protect against local disasters (e.g., equipment failure), establish appropriate monitoring and evaluation strategies. They conclude that "Implementation of such [conservation hatchery] programs would require significant capital expenditure, with increased hatchery operating costs and reduced fish production. Some increased costs would be offset by conservation hatcheries releasing smaller numbers of highly adaptable fish."

Construction and operational costs of a conservation hatchery depend on a variety of factors - e.g., whether the hatchery is newly constructed or a modification of an existing hatchery, which of the Flagg/Nash recommendations are implemented at the hatchery and the particular facilities and protocols needed for such implementation, scale of hatchery production, the particular species at the hatchery (since rearing time varies among species).

The Kingfisher Flat Hatchery on Big Creek operates an artificial propagation program to supplement depressed wild coho runs. The hatchery receives about $95K/year from the CDFG Fisheries Restoration Grants Program (Table RE-1). The extent to which the $95K reflects the cost of the hatchery's coho conservation program is difficult to determine, given that (1) the hatchery engages in other activities as well (e.g., chinook rearing), (2) the hatchery relies heavily on volunteer labor and also receives funding from other sources, (3) the SWFSC Santa Cruz's captive broodstock program provides gametes to the Kingfisher facility to increase coho genetic diversity (at no cost to the hatchery).

Table RE-2 describes capital and operating costs for a number of Columbia River hatcheries that are larger than Kingfisher Flat. While some of these hatcheries engage in some conservation activities, they are largely production hatcheries. Information provided in Table RE-2 is intended to give a very rough idea of hatchery costs.

Table RE-1. Hatchery Operation

Location	Year	Cost	Production	Source
Kingfisher Flat Hatchery	04-05	$94.3K/year	~240K chinook smolts, 45K steelhead smolts,100s coho smolts	CDFG-281
Kingfisher Flat Hatchery	05-06	$99K/year	~240K chinook smolts, 45K steelhead smolts,100s coho smolts	CDFG-276

Table RE-2. Columbia River Hatcheries (Source: IEAB 2002)			
Name/ Operator	Cost		
	Annual Cost: Annualized Capital (Cap)*, O&M, M&E	$/Released Fish	Production Goal
Spring Creek/ USFWS	$2.07M=$1.17M (Cap) +$900K (O&M)	$0.14	15M sub-yearling tule fall chinook
Clatsop Econ Development Council/ ClatsopCnty	AcclimationCosts: FallChin - $41.8K SprChin - $242K Coho - $98.4K FullCycleCosts: Coho - $124.2K	 $0.23 $0.28 $0.04 $0.18	 180K fall chinook smolts 850K spring chinook smolts 3.4M coho smolts
NezPerce/ tribe	$5.3M=$1.2M (Cap)+$2M (O&M)+$2.1M(M&E)	$2.60	1.4M fall chinook smolts 625K spring chinook smolts
Yakima/tribe	$4.7M=$1.5M (Cap) +$3.2M (O&M)	research facility	810K spring chinook smolts 700K coho smolts
Leavenworth/ USFWS	O&M by Facility: Leavenworth-$863K Entiat-$329K Winthrop-$430K (Built 1939-40, no capital cost, fully depreciated)	By Facility: $0.33 $0.46 $0.47	3M spring chinook smolts 200K summer steelhead smolts
PriestRapids/ WDFW	$527K=$210K (Cap) +$317K (O&M)	$0.08	3.7M fall chinook smolts
Irrigon/ ODFW	$1.95M=$794K (Cap) +$1.156K (O&M)	$1.30	1.7M summer steelhead smolts
McCall/ Idaho DFW	$899K=$418K (Cap) +$481K (O&M)	$1.09	8K adult summer chinook
* Annual capital costs, calculated as the original construction cost amortized over 50 years at 3%.			

WILDLIFE MANAGEMENT

The average cost per pikeminnow harvested in the Columbia River bounty program is $6.05/fish. Whether this cost estimate would be similarly applicable to a California eradication program would depend on the nature and scale of the program and the extent of angler interest and success in harvesting pikeminnow.

Table WM-1. Invasive Aquatic Species (e.g., pike minnow eradication)			
Location	Year	Cost Per Unit	Source
ColR	2005	Annual program cost (rewards+tags): $1,546,232 Avg $6.05/fish (=$1,460,724 total rewards/241,357 total fish harvested)	Porter, p41

RES - RESEARCH - productivity research (life cycle monitoring/analysis), spatial structure (fish distribution surveys), genetic diversity (laboratory analysis of tissue samples), and abundance estimates

Columns 2-3 of Table RES-1 describe start-up and annual costs of monitoring activities identified by CDFG/NMFS in several recent workshops. Several caveats in interpreting the cost estimates: (1) The estimates pertain only to coastal salmonids (i.e., exclude Central Valley), (2) the estimates are incremental in that they represent what is needed over and above what is currently being spent for coastal salmonid monitoring, and (3) the estimates assume that all labor is paid (no volunteers).

Monitoring costs are provided here because monitoring data are essential to conducting research on VSP (viable salmon population) attributes. Columns 4-7 of Table RES-1 identify which types of data are relevant to evaluating which VSP attribute. Because some of the data requirements relate to multiple VSP attributes, it is impractical to devise separate costs for each attribute.

As reflected in Table RES-1, the monitoring program is intended to follow different strategies in northern and southern areas. The northern area is defined as the Oregon border to Aptos Creek (five ESUs); the southern area is defined as the Pajara River southward (two ESUs). The boundaries of the two monitoring areas do not coincide with the boundaries of the recovery domains. However, it may be possible to allocate monitoring costs among domains (e.g., on the basis of proportion of total salmonid stream miles within each domain).

The costs noted in Table RES-1 are incomplete with regard to overall coastal salmonid research needs. Other activities mentioned in Boydstun and McDonald (2005) include: (1) habitat condition monitoring, (2) augmented samples for genetic monitoring, (3) other biological monitoring (e.g., otoliths, adult gender, length-weight samples), and (4) laboratory and computer analysis of data.

Table RES-1. Monitoring Activities and Costs as They Relate to Specific VSP Attributes Source: Boydstun & McDonald 2005 - pp 54-55 & Table8/p 58.						
Monitoring Activity	Estimated Cost		VSP Attribute			
	Startup	Annual	Abundance	Distri-bution	Genetic Diversity	Producti-vity
Northern spawner survey (OR border-Aptos Creek)	$566K	$2,545K	X	X	W/additnal sampling	X
Southern steelhead monitoring (PajaroR southward)	$65K	$541K	X			X
Life cycle monitoring stations (2 stns per coastal recovery domain)	$1,036K	$1,370K				X
Juvenile salmonid surveys	$177K	$1,307K	Cutthroat only*	X	W/additnal sampling	Cutthroat only*
25% hatchery fish marking (additional marking needed @ Iron Gate & Rowdy Creek only)	$0	$69K				X
Angler creel survey SmithR-SLO Creek, except Klamath/Trinity chinook/coho (already monitored by CDFG)	$14K	$369K				X
Administrative/ special studies	$36K	$789K				
* Assume monitoring from Eel River to Smith River and 30 miles inland.						

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