RECOVERY PLAN

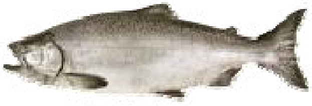
For The Evolutionarily Significant Units of

Sacramento River Winter-run Chinook Salmon
and
Central Valley Spring-Run Chinook Salmon

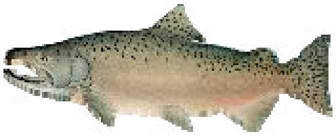
and

The Distinct Population Segment of

California Central Valley Steelhead



Winter-run



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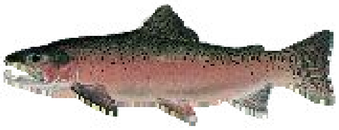

Steelhead

National Marine Fisheries Service

West Coast Region

Sacramento, California

July 2014

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List of Acronyms

AFRP	Anadromous Fish Restoration Program
Bay/Delta	San Francisco Bay/Sacramento-San Joaquin Delta
BRT	Biological Review Team
CALFED	CALFED Bay-Delta Program
CAMP	Comprehensive Assessment and Monitoring Program
CBDA	California Bay/Delta Authority
CCWD	Contra Costa Water District
CCWMG	Cow Creek Watershed Management Group
CDFW	California Department of Fish and Wildlife
CESA	California Endangered Species Act
CMARP	Comprehensive Monitoring Assessment and Research Program
cm	centimeters
cm/sec	centimeters per second
CNFH	Coleman National Fish Hatchery
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVSEPWT	Central Valley Salmonid Escapement Project Work Team
CWT	Coded Wire Tag
Delta	Sacramento-San Joaquin Delta
DPS	Distinct Population Segment
DWR	Department of Water Resources
ERP	Ecosystem Restoration Program
ESA	Federal Endangered Species Act
ESU	Evolutionarily Significant Unit
EWA	Environmental Water Account
FERC	Federal Energy Regulatory Commission
FL	fork length
FRFH	Feather River Fish Hatchery
ft/sec	feet per second
HGMPs	Hatchery and Genetic Management Plans
IEP	Interagency Ecological Program
LSNFH	Livingston Stone National Fish Hatchery
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
PRD	Protected Resources Division
PVA	Population Viability Analyses
QC	Quality Control
RBDD	Red Bluff Diversion Dam
Reclamation	Bureau of Reclamation
RM	River Mile
RST	Rotary Screw Trap
SWP	State Water Project
TRT	Technical Recovery Team
USACOE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USFS	U.S. Forest Service
VSP	Viable Salmonid Population

EXECUTIVE SUMMARY

Introduction: Recovery is the process by which listed species and their ecosystems are restored and their future is safeguarded to the point that protections under the Endangered Species Act (ESA) are no longer needed. The goal of this Recovery Plan is to recover the endangered Sacramento River winter-run Chinook salmon Evolutionarily Significant Unit (ESU), the threatened Central Valley spring-run Chinook salmon ESU, and the threatened California Central Valley steelhead Distinct Population Segment (DPS). Recovering these species and the Central Valley, San Francisco Bay-Delta Estuary, and Pacific Ocean ecosystems that support them will be challenging and will require shifts in societal values. Californians must work together towards a conservation ethic and practice that ensures wild salmon and steelhead are an important part of coastal California and Central Valley culture for many generations to come.

Background: The rivers draining the Great Central Valley of California ("Central Valley") and adjacent Sierra Nevada and Cascade Range once were renowned for their production of large numbers of Pacific salmon (Clark 1929; Skinner 1962 *in* Yoshiyama *et al.* 1998). The Central Valley rivers and creeks historically have been the source of most of the Pacific salmon produced in California waters (CDFW 1950, 1955; Fry and Hughes 1951; Skinner 1962; CDWR 1984 *in* Yoshiyama *et al.* 1998). Chinook salmon *(Oncorhynchus tshawytscha)* historically were, and remain today, the only abundant salmon species in the Central Valley (Eigenmann 1890; Rutter 1908 *in* Yoshiyama *et al.* 1998), although small numbers of other salmon species also have occurred occasionally in its rivers (Collins 1892; Rutter 1904a, 1908; Hallock and Fry 1967; Moyle *et al.* 1995 *in* Yoshiyama *et al.* 1998). Steelhead (anadromous *O. mykiss)* were common in Central Valley tributaries (USFC 1876; Clark 1973; Latta 1977; Reynolds *et al.* 1993 *in* Yoshiyama *et al.* 1998), but records for them are few and fragmented, partly because they did not support commercial fisheries (Yoshiyama *et al.* 1998).

Populations of native Chinook salmon and steelhead have declined dramatically since European settlement of the Central Valley in the mid-1800s. California's salmon resources began to decline in the late 1800s, and continued to decline in the early 1900s, as reflected in the decline of Chinook salmon commercial harvest. The total commercial catch of Chinook salmon in 1880 was 11 million pounds; by 1922 it had dropped to seven million pounds, and it reached a low of less than three million pounds in 1939 (Lufkin 1996).

Another major factor affecting anadromous salmonids during this period was hydraulic gold mining, which began in the 1850s. By 1859, an estimated 5,000 miles of mining flumes and canals diverted streams used by salmonids for spawning and nursery habitat. Habitat alteration and destruction also resulted from the use of hydraulic cannons, and from hydraulic and gravel mining, which leveled hillsides and sluiced an estimated 1.5 billion cubic yards of debris into the streams and rivers of the Central Valley (Lufkin 1996).

Despite the prohibition of hydraulic mining in 1894, habitat degradation continued. Habitat quantity and quality have declined due to: construction of levees and barriers to migration, modification of natural hydrologic regimes by dams and water diversions, elevated water temperatures, and water pollution from agriculture and industry (Lufkin 1996).

Although the effects of habitat degradation on fish populations were evident by the 1930s, rates of decline for most anadromous fish species increased following construction of major water project facilities (USFWS 2001), which primarily occurred around the mid- 1900s. Many of these water development projects completely blocked the upstream migration of Chinook salmon and steelhead to spawning and rearing habitats, and altered flow and water temperature regimes downstream from terminal dams. As urban and agricultural development of the Central Valley continued, numerous other stressors to anadromous salmonids emerged and continue to affect the viability of these fish today. Some of the more important stressors include: the high demand for limited water supply resulting in reduced instream flows, increased water temperatures, and highly altered hydrology in the Sacramento-San Joaquin Delta, barriers to historic habitat, widespread loss of tidal marsh, riparian and floodplain habitat, poor water quality, commercial and/or recreational harvest, and predation from introduced species such as striped bass.

Recovery Strategy: Recovery of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead across such a vast and altered ecosystem as the Central Valley will require a broadly focused, science-based strategy. The scientific rationale for the strategy in this plan focuses on two key salmonid conservation principles. The first is that functioning, diverse, and interconnected habitats are necessary for a species to be viable. That is, salmon and steelhead recovery cannot be achieved without providing sufficient habitat. Anadromous salmonids persisted in the Central Valley for thousands of years because the available habitat capacity and diversity allowed species to withstand and adapt to environmental changes including catastrophes such as prolonged droughts, large wildfires, and volcanic eruptions.

To help return the habitat capacity and diversity in the Central Valley to a level that will support viable salmon and steelhead, we have identified and prioritized recovery actions based on a comprehensive life stage-specific threats assessment. Minimizing or eliminating stressors to the fish and their habitat in an efficient and structured way is a key aspect of the recovery strategy.

The second salmonid conservation principle guiding the recovery strategy is that a species' viability is determined by its spatial structure, diversity, productivity, and abundance (McElhany *et al*. 2000). Abundance and population growth rate are self-explanatory parameters that are clearly important to species and population viability, while spatial structure and diversity are just as important, but less intuitive. Spatial structure refers to the arrangement of populations across the landscape, the distribution of spawners within a population, and the processes that produce these patterns. Species with a restricted spatial distribution and few spawning areas are at a higher risk of extinction from catastrophic environmental events (e.g., a single landslide) than are species with more widespread and complex spatial structure. Species or population diversity concerns the phenotypic (morphology, behavior, and life-history traits) and genetic characteristics of populations. Phenotypic diversity allows more populations to use a wider array of environments and protects populations against short-term temporal and spatial environmental changes. Genetic diversity, on the other hand, provides populations with the ability to survive long-term changes in the environment. It is the combination of phenotypic and genetic diversity expressed in a natural setting that provides populations with the ability to adapt to long-term changes (McElhany *et al.* 2000).

Bridging the gap between the species and population levels are population groups or salmonid ecoregions, which are delineated based on climatological, hydrological, and geological characteristics. The Central Valley Technical Recovery Team (TRT) identified four population groups (hereafter referred to as diversity groups) that Chinook salmon historically inhabited in the Central Valley:

- ☐ The basalt and porous lava diversity group composed of the upper Sacramento River, McCloud River, Pit River and Battle Creek watersheds;
- ☐ The northwestern California diversity group composed of streams that enter the mainstem Sacramento River from the northwest;
- ☐ The northern Sierra Nevada diversity group composed of streams tributary to the Sacramento River from the east, and including the Mokelumne River; and
- ☐ The southern Sierra Nevada diversity group composed of streams tributary to the San Joaquin River from the east.

Based on the two scientific principles described above and on a comparison of current species viability, relative to historic viability, the basic strategy put forth in this recovery plan is to secure all extant populations and to reintroduce populations to historic habitat such that each salmonid diversity group in the Central Valley supports viable populations. The TRT concluded that recovery of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead would require that no more populations are allowed to become extirpated and that habitat must be expanded to allow for the establishment of additional populations (Lindley *et al.* 2007).

The primary means of securing existing populations is to reduce or eliminate threats to those populations and their habitats. To help guide threat abatement efforts, watersheds and recovery actions have been prioritized. Watersheds that are currently occupied by at least one of the listed Chinook salmon and steelhead species have been prioritized among three levels. Of highest priority are core 1 populations, which have been identified, based on their known ability or potential to support independent viable populations. Core 1 populations form the foundation of the recovery strategy and must meet the population-level biological recovery criteria for low risk of extinction set out in Table 5-1. NMFS believes that core 1 populations should be the first focus of an overall recovery effort. Core 2 populations are assumed to have the potential to meet the moderate risk of extinction criteria set out in Table 5-1. These dependent populations are of secondary importance for recovery efforts. Core 3 populations are present on an intermittent basis and are characterized as being dependent on other nearby populations for their existence. The presence of these populations provides increased life history diversity to the ESU/DPS and is likely to buffer against local catastrophic occurrences that could affect other nearby populations. Connectivity between populations and genetic diversity may be enhanced by working to recover smaller core 3 populations that serve as stepping stones for dispersal. General guidance for how this watershed prioritization should be applied is that if a core 1 watershed and a core 2 (or 3) watershed had a similar problem affecting salmon and/or steelhead, then efforts should be directed at fixing the problem in the core 1 watershed first.

Unoccupied habitats that historically supported winter-run Chinook salmon, spring-run Chinook salmon, or steelhead have been prioritized regarding fish reintroductions. These unoccupied habitats have been prioritized as primary areas, candidates, or have been ruled out as places to reintroduce one or more of the species. Primary areas for reintroductions are areas where there is a known high likelihood of success based on species-specific life history needs, and available habitat quality and quantity. Specific primary reintroduction areas include the McCloud River, Battle Creek, the Yuba River, and the San Joaquin River. Candidate areas for reintroduction are unoccupied habitats that require further study of their potential for successful reintroductions. Some areas that were historically accessible to anadromous salmonids, but are no longer because of dams, have been excluded from consideration for reintroductions because they are so critically impaired by hydroelectric development and channel inundation that we felt efforts should be focused on areas with a higher potential for success.

Because recovery of winter- and spring-run Chinook salmon and steelhead will require implementation over a large landscape and over an extended period of time, a stepwise strategy has been adopted, based on the prioritization of watersheds and recovery actions. As this Recovery Plan is implemented over time, additional information will become available to help determine the degree to which the threats have been abated, to further develop understanding of the linkages between threats and population responses, to identify any additional threats, and to evaluate the viability of Chinook salmon and steelhead in the Central Valley.

Recovery Goals, Objectives, and Criteria: The overarching goal of this Recovery Plan is the removal of the Sacramento River winter-run Chinook salmon ESU, Central Valley spring-run Chinook salmon ESU, and California Central Valley steelhead DPS from the Federal List of Endangered and Threatened Wildlife (50 C.F.R. 17.11). The objectives and criteria to accomplish this goal builds upon the technical input and guidance provided by the TRT, and much of the following discussion is taken directly from information developed by the TRT (Lindley *et al.* 2004; 2006; 2007).

In order for the Chinook salmon ESUs and the steelhead DPS to achieve recovery, each diversity group must be represented, and population redundancy within the groups must be met to achieve diversity group recovery. Therefore, ESU-level recovery criteria include the following:

Winter-run Chinook salmon ESU:

- ❑ Three populations in the Basalt and Porous Lava Diversity Group at low risk of extinction

Spring-run Chinook salmon ESU and **Central Valley steelhead DPS**:

- ❑ One population in the Northwestern California Diversity Group at low risk of extinction

- ☐ Two populations in the Basalt and Porous Lava Diversity Group at low risk of extinction
- ☐ Four populations in the Northern Sierra Nevada Diversity Group at low risk of extinction
- ☐ Two populations in the Southern Sierra Nevada Diversity Group at low risk of extinction
- ☐ Maintain all Core 2 populations at moderate risk of extinction.

Recovery criteria at the population level were established by the Central Valley TRT and are included in this recovery plan (and apply to all three species), as described in Lindley *et al.* (2007). The TRT incorporated the four viable salmonid population parameters (McElhany *et al.* 2000) into assessments of population viability, and two sets of population viability criteria were developed, expressed in terms of extinction risk. The first set of criteria deal with direct estimates of extinction risk from population viability models. If data are available and such analyses exist and are deemed reasonable for individual populations, such assessments may be efficient for assessing extinction risk. In addition, the TRT also provided simpler criteria. The simpler criteria include population size (and effective population size), population decline, catastrophic rate and effect, and hatchery influence. For a population to be considered at low risk of extinction (i.e., < 5 percent chance of extinction within 100 years), the population viability assessment must demonstrate that risk level or all of the following criteria must be met:

- ☐ Census population size is >2,500 adults -or- Effective population size is >500
- ☐ No productivity decline is apparent
- ☐ No catastrophic events occurring or apparent within the past 10 years
- ☐ Hatchery influence is low (see Figure 4-1).

Additionally, threat abatement criteria must be met demonstrating that specific threats have been alleviated. The following threat abatement criteria have been established to ensure that each of the five ESA listing factors are addressed before a species can be delisted:

- ☐ Populations have unobstructed access to Core 1, 2, and 3 watersheds and assisted access to primary watersheds for reintroduction that are obstructed. Man-made structures (e.g., bridges and water diversions) affecting these watersheds and in migratory habitat must meet NMFS salmonid passage guidelines for stream crossings and screening criteria for anadromous salmonids (Listing Factors 1, 4, and 5)
- ☐ Utilization for commercial, recreational, scientific, and educational purposes is managed, such that all Core 1 populations meet the low extinction risk category for abundance (see Table 5-1) (Listing Factor 2)
- ☐ Hatchery programs are operated so that all Core 1 populations meet the low extinction risk criteria for hatchery influence (see Table 5-1) (Listing Factors 3 and 5)
- ☐ Migration and rearing corridors meet the life-history, water quality and habitat requirements of the listed species, such that the corridor

supports multiple viable populations (Listing Factors 1, 3, 4, and 5)

Recovery Actions: This Recovery Plan establishes a strategic approach to recovery, which identifies and prioritizes recovery actions at the Statewide, Central Valley wide, and site-specific levels. Three steps were taken to prioritize recovery actions as they are presented in this plan. First, results from the threats assessment and prioritization process (described in Appendix B) were used to guide the identification of watershed- and site-specific recovery actions for each diversity group and population. This step prioritized recovery actions separately for each species. The second step to prioritize recovery actions was undertaken through consideration of specific actions that benefit multiple species and populations. Results from the second step included tables of recovery actions listed in descending order of priority by geographic region (e.g., Delta, mainstem Sacramento River, Diversity Group) based on multiple species benefits. These first two steps were the only steps taken to prioritize recovery actions that were presented in the Co-Manager Review Draft Recovery Plan. Based on feedback from co-managers, it was apparent that the priority with which recovery actions should be undertaken was not clear. To address this, we implemented a third step and prioritized each of the region-specific recovery actions according to three categories. Priority 1 actions are those critical actions that address threats that generally ranked among the most important threats to one or more of the species; priority 2 actions address threats of moderate importance, and priority 3 actions are among the least important to implement. Actions were identified as priority 1, 2, or 3 based on the first two prioritization steps and on the best professional judgment of agency co-managers, including biologists from CDFW, USFWS, USFS, and NMFS.

Prioritized recovery actions for each of the following scales or regions are described in chapter 6 in the form of implementation tables: California-wide, Central Valley-wide, Pacific Ocean, San Francisco Bay, Delta, mainstem Sacramento River, mainstem San Joaquin River, and each of the four diversity groups. These implementation tables describe each action, the time frames and, if possible, the costs associated with it. Cost estimates have been provided wherever practicable, but in some cases where the uncertainties regarding the exact nature or extent of the recovery actions is unknown, these costs estimates can only be provided after site-specific investigations are completed.

Investment in recovery of salmon and steelhead will result in economic, societal and ecosystem benefits. Monetary investments in watershed restoration projects can promote the economy in a myriad of ways. These include stimulating the economy directly through the employment of workers, contractors and consultants, and the expenditure of wages and restoration dollars for the purchase of goods and services. Habitat restoration projects have been found to stimulate job creation at a level comparable to traditional infrastructure investments such as mass transit, roads, or water projects (Oregon Watershed Enhancement Board 2010). In addition, viable salmonid populations provide ongoing direct and indirect economic benefits as a resource for fish, recreation, and tourist related activities. Dollars spent on salmon and steelhead recovery will promote local, state, Federal and tribal economies, and should be viewed as an investment with both societal (clean rivers, healthy ecosystems) and economic returns.

The largest direct economic returns resulting from recovered salmon and steelhead are associated with sport and commercial fishing. On average 1.6 million anglers fish the Pacific region annually (Oregon, Washington and California) and 6 million fishing trips were taken annually between 2004 and 2006 (NMFS 2010a). Most of these trips were taken in California and most of the anglers lived in California. The California salmon fishery is estimated to generate $118 to $279 million in income annually, and provide roughly two to three thousand jobs (Michael 2010). With a revived sport and commercial fishery, these substantial economic gains and the creation of jobs would be realized across California, but most notably for river communities and rural coastal counties.

Many of the actions identified in this Recovery Plan are designed to improve watershed-wide processes which will benefit many native species of plants and animals (including other state and federally listed species) by restoring natural ecosystem functions. In addition, restoration of habitat in watersheds will provide substantial benefits for human communities. Some of these benefits are: improving and protecting the quality of important surface and ground water supplies; reducing damage from flooding resulting from floodplain development; and controlling invasive exotic animal and plant species which can threaten water supplies and increase flooding risk. Restoring and maintaining healthy watersheds also enhances important human uses of aquatic habitats, including outdoor recreation, ecological education, field based research, aesthetic benefits, and the preservation of tribal and cultural heritage.

The final category of benefits accruing to recovered salmon and steelhead populations are even more difficult to quantify and are related to the ongoing costs associated with maintaining populations that are at risk of extinction. Significant funding is spent annually by entities (Federal, State, local, private) in order to comply with the regulatory obligations that accompany populations that are listed under the ESA.

Important activities, such as water management for agriculture and urban use, are now constrained to protect ESA listed populations of salmon and steelhead. Examples of these types of obligations include such requirements as: ESA section 7 consultations, development and implementation of Habitat Conservation Plans, the provision of fish passage at impassible barriers, and a high degree of uncertainty for the regulated entities. Recovering the salmonid populations so the protections of the ESA are no longer necessary will also result in elimination of the regulatory requirements imposed by the ESA, and allow greater flexibility for land and water managers to optimize their activities and reduce costs related to ESA protections. Salmon recovery is best viewed as an opportunity to diversify and strengthen the economy while enhancing the quality of life for present and future generations.

Implementation: It is a challenging undertaking to facilitate a change in practice and policy that reverses the path towards extinction of a species to one of recovery. This change can only be accomplished with effective outreach and education, strong partnerships, focused recovery strategies and solution-oriented thinking that can shift agency and societal attitudes, practices and understanding. Implementation of the recovery plan by NMFS will take many forms and is described in the NMFS

Protected Resources Division (PRD) Strategic Plan 2006 (NMFS 2006). The Recovery Planning Guidance (NMFS 2010b) 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:

- ❑ Coordinating priorities and actions with the Anadromous Fish Restoration Program, the Ecosystem Restoration Program, and other key funding sources.
- ❑ Creating and maintaining partnerships with fish and water stakeholder groups, including Federal, State, and local governments, water agencies, fishing groups, and watershed conservation groups.
- ❑ 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).
- ❑ Supporting outreach and education programs.
- ❑ Facilitating a consistent framework for research, monitoring, and adaptive management that can directly inform recovery objectives and goals.
- ❑ Establishing an implementation tracking system that is adaptive, web-based, and pertinent to support the annual reporting for the Government Performance and Results Act, Biennial Recovery Reports to Congress and the 5-Year Status Reviews.

NMFS' efforts must be as far-reaching (beyond those under the direct regulatory jurisdiction of NMFS) as the issues adversely affecting the species. Thus, to achieve recovery, NMFS will need to promote the recovery plan and provide needed technical information and assistance to other entities that implement actions that may impact the species' recovery. For example, NMFS will work with key partners on high priorities such as facilitating passage assessment and working with Counties to ensure protective measures consistent with recovery objectives are included in their General Plans.

Many complex and inter-related biological, economic, social, and technological issues must be addressed in order to recover anadromous salmonids in the Central Valley. Policy changes at the Federal, State and local levels will be necessary to implement many of the recovery actions identified in this Recovery Plan. For example, without substantial strides in habitat restoration, fish passage, and changes in water use, recovery will be difficult if not impossible. In some cases, conflicting regulatory mandates that influence water and aquatic resources management will need to be resolved. Most importantly, recovering winter-run Chinook salmon, spring-run Chinook salmon, and steelhead will require a focused effort that secures existing populations, re-establishes populations in watersheds that historically supported them, and restores the ecological function of the habitats upon which the species depend for their long-term survival.

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1.0 Introduction

> *"Salmon was now abundant in the Sacramento. Those which we obtained were generally between three and four feet in length, and appeared to be of two distinct kinds. It is said that as many as four different kinds ascend the river at different periods. The great abundance in which this fish is found gives it an important place among the resources of the country."*
>
> - Captain John C. Frémont, memoirs for 30 March-5 April 1846 *in* Yoshiyama et al. 1998

The rivers draining the Great Central Valley of California ("Central Valley") and adjacent Sierra Nevada and Cascade Range once were renowned for their production of large numbers of Pacific salmon (Clark 1929; Skinner 1962 *in* Yoshiyama *et al.* 1998). The Central Valley system historically has been the source of most of the Pacific salmon produced in California waters (CDFW 1950, 1955; Fry and Hughes 1951; Skinner 1962; CDWR 1984 *in* Yoshiyama *et al.* 1998).

Chinook salmon *(Oncorhynchus tshawytscha)* historically were, and remain today, the only abundant salmon species in the Central Valley system (Eigenmann 1890; Rutter 1908 *in* Yoshiyama *et al.* 1998), although small numbers of other salmon species also have occurred occasionally in its rivers (Collins 1892; Rutter 1904a, 1908; Hallock and Fry 1967; Moyle *et al.* 1995 *in* Yoshiyama *et al.* 1998). Steelhead (anadromous *O. mykiss)* apparently were common in Central Valley tributaries (USFC 1876; Clark 1973; Latta 1977; Reynolds *et al.* 1993 *in* Yoshiyama *et al.* 1998), but records for them are few and fragmented, partly because they did not support commercial fisheries (Yoshiyama *et al.* 1998).

Anadromous salmonids, in particular Chinook salmon, have and continue to be an important resource, both revered and harvested by humans. The Native American people depended upon these fishes for subsistence, ceremonial, and trade purposes. Prior to Euro-American settlement, Native Americans within the Central Valley drainage harvested Chinook salmon at estimated levels that reached 8.5 million pounds or more annually (Yoshiyama *et al.* 1998). With the advent of the California gold rush in the mid-1800s, a commercial Chinook salmon fishery developed in the San Francisco Bay and Sacramento-San Joaquin Delta ("Delta") region. Annual catches by the early in-river fisheries commonly reached 4-10 million pounds. The first west coast salmon cannery opened on a scow moored near Sacramento in 1864. Within 20 years, 19 canneries were operating in the Delta region, and processed a peak of 200,000 cases (each case comprised of 48, 1-pound cans) in 1882 (Lufkin 1996). The salmon fishery remained centered in the Delta region until the early 1900s, when ocean salmon fishing began to expand and eventually came to dominate the fishery.

1.1 The Great Central Valley of California

The northern half of the Central Valley is comprised of the Sacramento River Basin (covering approximately 24,000 square miles [mi^2]), with the southern half (covering approximately 13,540 mi^2) primarily composed of the San Joaquin River Basin (**Figure 1-1**). The broad expanse of the Central Valley region of California once encompassed numerous salmon-producing streams that drained the Sierra Nevada and Cascade mountains on the east and north and, to a lesser degree, the lower-elevation Coast Range on the west. The large areal extent of the Sierra Nevada and Cascades watersheds, coupled with regular, heavy snowfalls in those regions, provided year-round streamflows for a number of large rivers which supported substantial runs of Chinook salmon (Yoshiyama *et al.* 1998).

Figure 1-1. Central Valley Region of California

In the Sacramento River Basin, most Coast Range streams historically supported regular salmon runs, although their runs were limited by the volume and seasonal availability of streamflows due to the lesser amount of snowfall west of the valley (Yoshiyama *et al.* 1998). In the San Joaquin River Basin, a number of major streams (e.g., the Merced, Tuolumne, and upper San Joaquin rivers) sustained very large salmon populations, while other streams with less regular streamflows had intermittent salmon runs in years when rainfall provided sufficient flows. All of the west side San Joaquin River Basin streams flowing from the Coast Range were highly intermittent (Elliott 1882) and none are known to have supported anadromous salmonids (Yoshiyama *et al.* 1998).

1.2 Salmon & Steelhead at Risk

Since settlement of the Central Valley in the mid-1800s, populations of native Chinook salmon and steelhead have declined dramatically. California's salmon resources began to decline in the late 1800s, and continued to decline in the early 1900s, as reflected in the decline of commercial harvest. The total commercial catch of Chinook salmon in 1880 was 11 million pounds, by 1922 it had dropped to 7 million pounds, and reached a low of less than 3 million pounds in 1939 (Lufkin 1996).

History and Current Status of Commercial Harvest

Although Chinook salmon remain an important resource, fishing for salmon has changed, most notably, in the last 20 years. 28 evolutionarily significant units (ESU'S) and distinct population segments (DPS's) of salmonids have been listed under the List of Endangered and Threatened Wildlife by the National Marine Fisheries Service (NMFS) on the West Coast of the United States since 1989. This is significant because commercial ocean harvest and sport fishing for salmon has undergone dramatic management and regulatory implementations in order to continue with the commercial fishery while at the same time finding and implementing an exploitation rate that enables sustained Chinook populations into the future. It is also now possible for the ocean fishery to be managed for specific river fisheries through genetic sampling of the ocean harvest along the Pacific Coast. This change has altered the way ocean harvest is regulated, and further protects critical species in that life stage.

New matrixes developed by the National Oceanic and Atmospheric Administration (NOAA) Pacific Northwest Region emphasize that commercial fishing or ocean harvest is a critical parameter in the decisions used to manage sustainable fisheries or to reestablish adequate escapement levels.

Commercial and recreational ocean salmon fisheries in the U.S. Exclusive Economic Zone off the coasts of Washington, Oregon, and California are authorized by NMFS under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). Specifically, these fisheries are managed under the Federal Pacific Coast Salmon Fishery Management Plan (FMP) (PFMC 2003). Consistent with the FMP, detailed management regulations are developed annually, designed to respond to new information and the current status of each salmon stock. Pursuant to the MSA, the Pacific Fishery Management Council (PFMC) develops recommendations for the development of the FMP, FMP amendments, and annual management measures and provides those recommendations to the Secretary of Commerce, through NMFS, for review and approval. The Secretary may approve the PFMC's recommendations for implementation as federal regulation if found to be consistent with the MSA and other applicable law, including the ESA.

The number of Chinook salmon harvested in the California commercial salmon fishery dramatically declined starting in 2006. From 1978 to 2005, the annual salmon harvest for the California commercial fishery exceeded 300,000 in all but one year (2001). In 2006 the fishery collapsed resulting in complete fishery closures in 2008 and 2009, and a heavily restricted fishery in 2010. The average Chinook salmon harvest in the fishery in 2006, 2007, and 2011 was approximately 85,000 (PFMC 2012).

Sources of Habitat Decline

A major factor affecting Chinook salmon and steelhead was hydraulic gold mining, which began in the 1850s. By 1859, an estimated 5,000 miles of mining flumes and canals diverted streams used by salmonids for spawning and nursery habitat. Habitat alteration and destruction also resulted from the use of hydraulic cannons, which leveled hillsides and sluiced an estimated 1.5 billion cubic yards of debris into the streams and rivers of the Central Valley (Lufkin 1996).

Evan though hydraulic mining was prohibited in 1894, other habitat degradation continued. Habitat quantity and quality have declined due to construction of levees and barriers to migration, modification of natural hydrologic regimes by dams and water diversions, elevated water temperatures, and water pollution (Lufkin 1996). Although the effects of habitat degradation on fish populations were evident by the 1930s, rates of decline for most anadromous fish species increased following completion of major water project facilities (USFWS 2001) which primarily occurred around the mid- 1900s.

Numerous water development projects blocked the upstream migration of Chinook salmon and steelhead, and altered flow and water temperature regimes downstream from terminal dams. An extensive network of reservoirs and aqueducts has been developed throughout much of California to provide water to major urban and agricultural areas. The two largest water projects in California are the State Water Project (SWP) and the Federal Central Valley Project (CVP). The CVP delivers on average over 7 million acre-feet per year. CVP water is used to irrigate 3 million acres of farmland in the San Joaquin Valley, as well as provide water for urban use in Contra Costa, Santa Clara, and Sacramento counties. The largest state-built water and power project in the United States, the SWP spans 600 miles from Northern California to Southern California, providing drinking water for 23 million people and irrigation water for 750,000 acres of farmland (see www.aquafornia.com for more information about California water management).

An estimated 1,126 miles of stream remain of the more than 2,183 miles of Central Valley streams that were historically accessible by Chinook salmon – indicating an overall loss of at least 1,057 miles (48 percent) of the original total (Yoshiyama *et al.* 2001). The estimated habitat loss includes the lengths of stream used by salmon mainly as migration corridors, in addition to holding and spawning habitat. This estimated loss of habitat does not include the Delta, comprising about 700 miles of river channels and sloughs (USFWS 1995), available to various degrees as migration corridors or rearing areas for Chinook salmon and steelhead.

It is likely that the lower reaches of the Sacramento and San Joaquin rivers historically were used as rearing areas (at least during some flow regimes) as the juveniles moved downstream, but recently they have been less suitable for rearing due to alterations in channel morphology and other degraded environmental conditions. In terms of only spawning and holding habitat, the proportionate loss of historically available habitat far exceeds 48 percent, much of which was located in upper stream reaches that have been rendered inaccessible by terminal dams (Yoshiyama *et al.* 2001). Excluding the lower stream reaches that were used as adult migration corridors (and, to a lesser degree, for juvenile rearing), it has been estimated that at least 72 percent of the original Chinook salmon spawning and holding habitat in the Central Valley drainage is no longer available (Yoshiyama *et al.* 2001).

The amount of steelhead habitat lost most likely is much higher than that for Chinook salmon, because steelhead were undoubtedly more extensively distributed. Due to their superior leaping and swimming ability and the timing of their upstream migration, which coincided with the winter rainy season, steelhead likely used at least hundreds of miles of smaller tributaries not accessible to even the highest migrating winter-run and spring-run Chinook salmon (Yoshiyama *et al.* 2001).

In addition to commercial exploitation, large-scale habitat degradation, blockage of historically available habitat and altered flow and water temperature regimes, other factors that may have adversely affected natural stocks of Chinook salmon and steelhead include overharvest, illegal harvest, hatchery production, entrainment, and introduction of competitors, predators and diseases. Fish populations also vary due to natural events, such as droughts and poor ocean conditions (e.g., El Niño). However, populations in healthy habitats typically recover within a few years after natural events. In the Central Valley, the decline of fish populations has continued through cycles of beneficial and adverse natural conditions, indicating the need to improve habitat (USFWS 2001).

1.3 The Recovery Planning Process

The Federal Endangered Species Act of 1973 (ESA), as amended (16 U.S.C. 1531 *et seq.*) mandates the National Oceanic and Atmospheric Administration (NOAA), National Marine Fisheries Service (NMFS) to develop and implement plans (i.e., recovery plans) for the conservation and survival of NMFS listed species. Winter-run Chinook salmon are listed as endangered under the Federal ESA, and spring-run Chinook salmon and steelhead are listed as threatened. Implementation of the Recovery Plan for the Sacramento River winter-run Chinook salmon Evolutionarily Significant Unit (ESU), Central Valley spring-run Chinook salmon ESU, and California Central Valley steelhead Distinct Population Segment[1] (DPS) is vital to the continued persistence and recovery of these populations.

The recovery plan is a comprehensive plan that serves as a road map for species recovery – it lays out where we need to go and how best to get there. A recovery plan is one of the most important tools to ensure sound scientific and logistical decision-making throughout the recovery process. Primarily, a recovery plan should do the following:

- Delineate those aspects of the species' biology, life history, and threats that are pertinent to its endangerment and recovery;

- Outline and justify a strategy to achieve recovery;

- Identify the actions necessary to achieve recovery of the species; and

- Identify goals and criteria by which to measure the species' achievement of recovery (NMFS 2010b).

Although recovery plans provide guidance, they do not have the force of law. The success of this Recovery Plan depends upon the cooperation of all stakeholders and regulatory entities to ensure appropriate implementation.

Pursuant to Section 4(f) of the ESA, a recovery plan must be developed and implemented for the conservation and survival of species listed as threatened or endangered unless it finds that a recovery plan will not promote the conservation of the species. A recovery plan must, to the maximum extent practicable, include the following:

- ☐ A description of site-specific management actions necessary for recovery;
- ☐ Objective, measurable criteria, which when met, will allow delisting of the species; and
- ☐ Estimates of the time and cost to carry out the recovery measures.

The purpose of this Recovery Plan is to guide implementation of recovery of the species by resolving the threats to the species and thereby ensuring viable Chinook salmon ESUs and the steelhead DPS. This Recovery Plan may be used to inform all stakeholders including Federal, State, Tribal, and local agencies and land use actions, but it does not place regulatory requirements on such entities.

Past recovery plans generally have focused on the abundance, productivity, habitat and other life history characteristics of a species. While knowledge of these characteristics is certainly important for making sound conservation management decisions, the long-term

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[1] On January 5, 2006, NMFS departed from their previous practice of applying the ESU policy to steelhead. NMFS concluded that within a discrete group of steelhead populations, the resident and anadromous life forms of steelhead remain "markedly separated" as a consequence of physical, ecological and behavioral factors, and may therefore warrant delineation as a separate DPS (71 FR 834).

sustainability of a species in need of recovery can only be ensured by alleviating the threats that are contributing to the status of the species as threatened or endangered. Therefore, the identification of the threats to the species is a key component of this Recovery Plan.

To be most useful for recovery planning, a threats assessment should be used to determine the relative importance of various threats to a species. A threats assessment includes: (1) identifying threats and their sources; (2) evaluating the effects of threats; and (3) ranking each threat based on relative effects. The Interim Endangered and Threatened Species Recovery Planning Guidance (NMFS 2010b) recommends "*…using a threats assessment for species with multiple threats to help identify the relative importance of each threat to the species' status, and, therefore, to prioritize recovery actions in a manner most likely to be effective for the species' recovery*." This Recovery Plan uses this recommended approach to identify and prioritize threats to the Sacramento River winter-run Chinook salmon and Central Valley spring-run Chinook salmon ESUs, and the California Central Valley steelhead DPS. The prioritized threats are then used to guide the identification of specific recovery actions.

The methodology used in the threats assessment for this Recovery Plan is generally described in the next chapter (Background) and is fully described in Appendix B.

1.3.1 A Collaborative Effort

Central Valley Technical Recovery Team

As part of its recovery planning efforts, the NMFS Southwest Region (now part of the West Coast Region) designated the Central Valley as a "Recovery Domain." The NMFS Southwest Region established the Central Valley Technical Recovery Team (TRT) to provide technical assistance to the recovery planning process for the Central Valley Domain. The NMFS' intent in establishing the Central Valley TRT was to seek unique geographic and species expertise, and to develop a solid scientific foundation for the Recovery Plan. The Central Valley TRT identified unique habitat and biological characteristics of the three species, made technical findings regarding limiting factors and stressors for each ESU and DPS and its component populations, recommended biological viability criteria at the ESU/DPS- and population-level, and provided scientific review of local and regional recovery planning efforts.

The Central Valley TRT, a collaborative body of biologists that were selected based on their expertise and local knowledge, produced three documents heavily relied upon in preparation of the Recovery Plan: (1) *Population Structure of Threatened and Endangered Chinook Salmon ESUs in California's Central Valley Basin* (Lindley *et al.* 2004); (2) *Historical Population Structure of Central Valley Steelhead and its Alteration by Dams* (Lindley *et al.* 2006); and (3) *Framework for Assessing Viability of Threatened and Endangered Chinook Salmon and Steelhead in the Sacramento-San Joaquin Basin* (Lindley *et al.* 2007).

Public Participation

NMFS conducted a series of Recovery Planning Workshops, designed as round-table discussions, to solicit information and promote dialogue as part of the development of the Federal Recovery Plan for winter-run Chinook salmon, spring-run Chinook salmon and steelhead in the Central Valley Domain. Public workshops were held in Sacramento, California on July 20, 2006, in Redding, California on August 15, 2006, and in

Stockton, California on August 17, 2006. At these workshops, NMFS provided a general overview of: (1) the Federal recovery planning process; (2) the timeline for NMFS recovery plan development; (3) the current understanding of Chinook salmon and steelhead populations and their habitats; and (4) threats identified in original ESA listing documents.

Following the overviews, workshop participants were separated into smaller facilitated discussion groups to generate more in-depth dialogue and identify threats to specific Chinook salmon and steelhead populations and their habitats.

Information obtained at the initial series of workshops also was used in additional workshops to develop recovery actions that reduce or eliminate identified threats. These additional workshops were held in Sacramento, California on May 22, 2007 and in Redding, California on May 24, 2007.

In October of 2009, NMFS released a Public Draft Recovery Plan for Central Valley salmon and steelhead, commencing a 60-day public review and comment period (74 FR 51553; October 7, 2009). Based on requests from the public for additional review time, this comment period was extended an additional 60 days (74 FR 61329; November 24, 2009). NMFS received 78 written comment submissions from the public as well as several verbal comments. Many of the public comments and suggested edits have strengthened this Recovery Plan. Following release of the Public Draft Recovery Plan, a total of eight public workshops were held in Sacramento (three workshops), Chico (three workshops), Salida, and Mt. Shasta to help establish working relationships with local communities and to obtain stakeholder input.

Existing Efforts

Local water agencies and irrigation districts, municipal and county governmental agencies, watershed groups, and State and Federal agencies have undertaken major habitat restoration efforts in many parts of the Central Valley and Delta. These actions include the addition of gravel below dams, removal of small dams, screening water diversions, fish passage improvements, riparian revegetation, bank protection, structural habitat enhancement, restoration of floodplain and tidal wetlands, development and implementation of new flow and water temperature requirements below dams, and operational constraints in the Delta. Major restoration efforts that impact salmon and steelhead recovery throughout the Central Valley include the programs established under the Anadromous Fish Restoration Program (AFRP) of the Central Valley Project Improvement Act (CVPIA) and the Ecosystem Restoration Program (ERP). Shared purposes of the AFRP and the ERP are to protect and restore diversity within and among the various naturally-producing populations of Chinook salmon and steelhead in the Central Valley, and to restore the habitats upon which the populations depend.

The AFRP promotes collaboration between the Department of Interior (USFWS and the Bureau of Reclamation [Reclamation]) with other agencies, organizations and the public to increase natural production of anadromous fish in the Central Valley by augmenting and assisting restoration efforts presently conducted by local watershed workgroups, the California Department of Fish and Wildlife (CDFW), and others. Purposes of the CVPIA (Section 3402) relevant to the AFRP are: (1) to protect, restore, and enhance fish, wildlife, and associated habitats in the Central Valley; (2) to address impacts of the CVP on fish, wildlife, and associated habitats; (3) to improve the operational flexibility of the

CVP; (4) to contribute to the State of California's interim and long-term efforts to protect the San Francisco Bay and Sacramento-San Joaquin Delta Estuary; and (5) to achieve a reasonable balance among competing demands for the use of CVP water, including the requirements of fish and wildlife, agricultural, municipal and industrial, and power contractors (USFWS 2001).

The ERP is CDFW's principal program designed to restore the ecological health of the Bay/Delta ecosystem. The ERP includes actions throughout the Bay/Delta watershed and focuses on the restoration of ecological processes and important habitats. In addition, the ERP aims to reduce the effects of stressors that inhibit ecological processes, habitats and species (CALFED 1999b).

Another major effort that could impact Central Valley salmon and steelhead recovery, if implemented, is the Bay Delta Conservation Plan (BDCP). The dual goals of the BDCP are to provide a comprehensive ecosystem restoration program for the delta and a reliable water supply. Further information is available at the BDCP website: http://baydeltaconservationplan.com/.

1.4 Recovery Plan Content

This introductory chapter provides an overview of many important facets of this Recovery Plan, and in particular describes the collaborative processes of the plan. The remainder of this Recovery Plan for the Sacramento River winter-run Chinook salmon ESU, the Central Valley spring-run Chinook salmon ESU and the California Central Valley steelhead DPS is presented in several chapters.

The second chapter provides background including the current regulatory status, a description of the population trends and distribution of each species, and a description of the life history and habitat requirements for each species. A brief description of the reasons for listing and a current threats assessment is then presented (a detailed threats assessment is presented in Appendix B). Finally, current conservation efforts and biological constraints are discussed, including limiting factors that should be considered for the species recovery.

Next, the Recovery Strategy Chapter presents and justifies the recommended recovery program for each species. This chapter also describes the key facts, concepts and assumptions upon which the recovery program is based.

The following chapter describes the recovery goals, objectives, and criteria. The ultimate goal of the Recovery Plan is delisting of the Chinook salmon ESUs and the steelhead DPS. The recovery objectives basically subdivide the goal into discrete components which collectively describe the conditions necessary for delisting. Recovery criteria are the objective and measurable standards upon which decisions to delist the ESUs and DPS are based.

Next, the specific actions that should be implemented to achieve recovery are presented in the Recovery Actions Chapter. That chapter is intended to satisfy the requirement under the ESA (Section 4 (f)(1)(B)(iii)) that Recovery Plans must contain to the maximum extent practicable "*…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.*" Recovery actions are linked to the identified threats (or stressors) individually for specific populations of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead within the Central Valley Domain, and are prioritized according to the priority of threats addressed.

This Recovery Plan includes a chapter discussing the impacts of climate change on Central Valley salmonids, including how those impacts are expected to affect recovery efforts in the coming decades.

Lastly, a chapter on how this plan will be implemented is provided. The chapter discusses the time and cost to recovery, the benefits of recovery, and the various tools under the ESA that can be used to implement anadromous salmonid recovery in the Central Valley.

2.0 Background

> *"The requirement for determining that a species no longer requires the protection of the ESA is that the species no longer be in danger of extinction or likely to become endangered in the foreseeable future based on evaluation of the listing factors specified in ESA Section 4(a)(1). Any new factors identified since listing must also be addressed in this analysis to ensure that the species no longer requires protection."*
>
> \- NMFS Supplement to the Lower Columbia Salmon Recovery and Fish and Wildlife Subbasin Plan 2005

The Central Valley Domain encompasses the Sacramento River winter-run Chinook salmon ESU, Central Valley spring-run Chinook salmon ESU, and California Central Valley steelhead DPS. Following are descriptions of the current regulatory status, life histories, population trends and distribution, and the habitat requirements for winter- and spring-run Chinook salmon, and steelhead in the Central Valley. A brief description of the reasons for listing and a current threats assessment is then presented (a detailed threats assessment is presented in Appendix B). Finally, current conservation efforts and biological constraints are discussed, including limiting factors that should be considered for recovery of winter-run and spring-run Chinook salmon, and steelhead within the Central Valley Domain.

2.1 Winter-run Chinook Salmon

2.1.1 ESA Listing Status

The Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*) ESU, currently listed as endangered, was listed as a threatened species under emergency provisions of the ESA in August 1989 (54 FR 32085: August 4, 1989) and listed as a threatened species in a final rule in November 1990 (55 FR 46515; November 5, 1990). In June 1992, NMFS proposed that winter-run Chinook salmon be reclassified as an "endangered"[2] species (57 FR 27416; June 19, 1992). NMFS finalized its proposed rule and re-classified winter-run Chinook salmon as an endangered species on January 4, 1994 (59 FR 440). NMFS concluded that winter-run Chinook salmon in the Sacramento River warranted listing as an endangered species due to several factors, including: (1) the continued decline and increased variability of run sizes since its first listing as a threatened species in 1989; (2) the expectation of weak returns in future years as the result of two small year classes (1991 and 1993); and (3) continued threats to the winter-run Chinook salmon.

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[2] Under the ESA, an "endangered species" is, with the exception of insects determined to be pests, "…any species which is in danger of extinction throughout all or a significant portion of its range…" (16 USC § 1532(6)).

On June 14, 2004, NMFS issued a proposed rule to reclassify the listing status of winter-run Chinook salmon from endangered to threatened (69 FR 33102). To prevent further decline of the ESU by preventing take of this species from activities that harm fish and fish habitat, NMFS proposed to apply the ESA Section 9(a) take prohibitions with specific limitations to winter-run Chinook salmon under ESA Section 4(d) (69 FR 33102).

Following a series of extensions to the public comment period on the proposed listing determinations, the public comment period closed during November 2004 (69 FR 61348; October 18, 2004). On June 28, 2005, NMFS issued a final listing determination for the Sacramento River winter-run Chinook salmon ESU, which concluded that the Sacramento River winter-run Chinook salmon ESU is “in danger of extinction” due to risks to the ESU’s diversity and spatial structure and, therefore, continues to warrant listing as an endangered species under the ESA (70 FR 37160). Additionally, the Sacramento River Winter-run Chinook salmon was listed as endangered under the California ESA in 1989.

The Sacramento River winter-run Chinook salmon ESU includes winter-run Chinook salmon spawning naturally in the Sacramento River and its tributaries, as well as winter-run Chinook salmon that are part of the conservation hatchery program at the Livingston Stone National Fish Hatchery (LSNFH) (70 FR 37160). The Sacramento River winter-run Chinook salmon ESU is depicted in **Figure 2-1**.

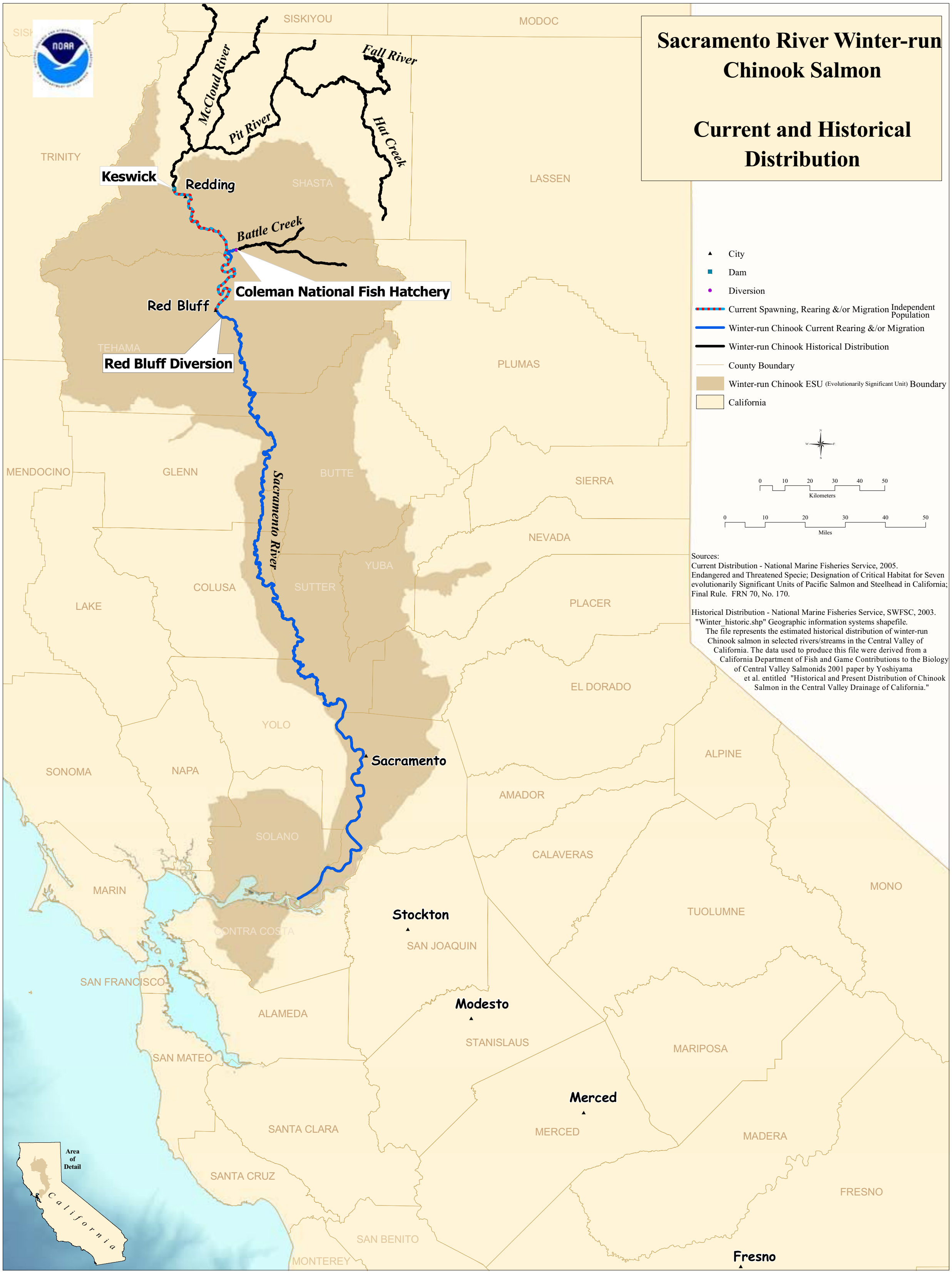
2.1.2 Species Description and Taxonomy

Chinook salmon, also referred to as king salmon in California, are the largest of the Pacific salmon. The following physical description of the species is provided by Moyle (2002). Spawning adults are olive to dark maroon in color, without conspicuous streaking or blotches on the sides. Spawning males are darker than females, and have a hooked jaw and slightly humped back. There are numerous small black spots in both sexes on the back, dorsal fins, and both lobes of the tail. They can be distinguished from other spawning salmon by the color pattern, particularly the spotting on the back and tail, and by the dark, solid black gums of the lower jaw. Parr have 6 to 12 parr marks, each equal to or wider than the spaces between them and most centered on the lateral line. The adipose fin of parr is pigmented on the upper edge, but clear at its base. The dorsal fin occasionally has one or more spots on it but the other fins are clear.

2.1.3 Life History/Habitat Requirements

Chinook salmon is the most important commercial species of anadromous fish in California. Chinook salmon have evolved a broad array of life history patterns that allow them to take advantage of diverse riverine conditions throughout the year. Four principal life history variants are recognized and are named for the timing of their upstream migration: fall-run, late fall-run, winter-run, and spring-run. The Sacramento River supports all four runs of Chinook salmon. The larger tributaries to the Sacramento River (American, Yuba, and Feather rivers) and rivers in the San Joaquin Basin also provide habitat for one or more of these runs.

Winter-run Chinook salmon are unique because they spawn during summer months when air temperatures usually approach their yearly maximum. As a result, winter-run Chinook salmon require stream reaches with cold water sources that will protect embryos and juveniles from the warm ambient conditions in summer.



Sources:
Current Distribution - National Marine Fisheries Service, 2005.
Endangered and Threatened Specie; Designation of Critical Habitat for Seven evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule. FRN 70, No. 170.

Historical Distribution - National Marine Fisheries Service, SWFSC, 2003. "Winter_historic.shp" Geographic information systems shapefile. The file represents the estimated historical distribution of winter-run Chinook salmon in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a California Department of Fish and Game Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California."

Figure 2-1. Current and Historical Sacramento River Winter-run Chinook Salmon Distribution.

Table 2-1 depicts the temporal occurrence of winter-run Chinook salmon life stages in the Sacramento River. Adult winter-run Chinook salmon immigration and holding (upstream spawning migration) through the Delta and into the lower Sacramento River occurs from December through July, with a peak during the period extending from January through April (USFWS 1995). Winter-run Chinook salmon are sexually immature when upstream migration begins, and they must hold for several months in suitable habitat prior to spawning. Winter-run Chinook salmon primarily spawn in the mainstem Sacramento River between Keswick Dam (River Mile [RM] 302) and the Red Bluff Diversion Dam (RBDD) (RM 243). Spawning occurs between late-April and mid-August, with a peak in June and July as reported by CDFW annual escapement surveys (2000-2006). Winter-run Chinook salmon embryo incubation in the Sacramento River can extend into October (Vogel and Marine 1991).

Winter-run Chinook salmon fry rearing in the upper Sacramento River exhibit peak abundance during September, with fry and juvenile emigration past RBDD primarily occurring from July through November (Poytress and Carillo 2010, 2011, 2012). Emigration of winter-run Chinook salmon juveniles past Knights Landing, located approximately 155.5 river miles downstream of the RBDD, reportedly occurs between November and March, peaking in December, with some emigration continuing through May in some years (Snider and Titus 2000a; Snider and Titus 2000c).

A description of freshwater habitat requirements for winter-run Chinook salmon is presented in the following sections. Habitat requirements are organized by life stage.

Adult Immigration and Holding

Suitable water temperatures for adult winter-run Chinook salmon migrating upstream to spawning grounds range from 57°F to 67°F (NMFS 1997). However, winter-run Chinook salmon are immature when upstream migration begins, and need to hold in suitable habitat for several months prior to spawning. The maximum suitable water temperature reported for holding is 59°F to 60°F (NMFS 1997). Because water temperatures in the lower Sacramento River below the RBDD generally begin exceeding 60 degrees Fahrenheit (°F) in April, it is likely that little, if any, suitable holding habitat exists in the lower Sacramento River. It most likely is only used by adults as a migration corridor. Following installation of the water temperature control device on Shasta Dam in 1997, it is possible that some deep water pool habitat may exist for a short distance downstream of the RBDD with suitable cold water temperatures for adult holding.

Adult Chinook salmon reportedly require water deeper than 0.8 feet and water velocities less than 8 feet per second (ft/sec) for successful upstream migration (Thompson 1972). Adult Chinook salmon are less capable of negotiating fish ladders, culverts, and waterfalls during upstream migration than steelhead, due in part to slower swimming speeds and inferior jumping ability (Bell 1986; Reiser *et al.* 2006).

Chinook salmon generally hold in pools with deep, cool, well-oxygenated water. Holding pools for adult Chinook salmon have reportedly been characterized as having moderate water velocities ranging from 0.5 to 1.3 ft/sec (DWR 2000).

Table 2-1. The Temporal Occurrence of Adult and Juvenile Sacramento River Winter-run Chinook Salmon in the Sacramento River

Winter run relative abundance	■ High				▨ Medium				░ Low			
a) Adult freshwater												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River basin[a,b]	▨	▨	▨	▨	▨	▨	▨				▨	▨
Sacramento River spawning[c]					■	■	■	▨				
b) Juvenile migration												
Location	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sacramento River@ Red Bluff[d]	░	░	░				▨	▨	▨	▨	▨	▨
Sacramento River @ Knights Landing[e]	■	▨	░							░	▨	■
Sacramento trawl @ Sherwood Harbor[f]	▨	■	■	░							▨	■
Midwater trawl @Chipps Island[g]	▨	▨	■	■	░							░

Sources: [a] (Yoshiyama *et al.* 1998); (Moyle 2002); [b](Myers *et al.* 1998) ; [c] (Williams 2006) ; [d] (Martin *et al.* 2001); [e] Knights Landing Rotary Screw Trap Data, CDFW (1999-2011)); [f,g] Delta Juvenile Fish Monitoring Program(DJFMP), USFWS (1995-2012)

Spawning

Spawning occurs from mid-April to mid-August, peaking in June and July, in the Sacramento River reach between Keswick Dam and RBDD (Vogel and Marine 1991; CDFW Annual escapement survey reports, 2000-2006). Chinook salmon spawn in clean, loose gravel, in swift, relatively shallow riffles, or along the margins of deeper river reaches where suitable water temperatures, depths, and velocities favor redd construction and oxygenation of incubating eggs. Winter-run Chinook salmon were adapted for spawning and rearing in the clear, spring-fed rivers of the upper Sacramento River Basin, where summer water temperatures were typically 50°F to 59°F. Water temperature conditions were created by glacial and snowmelt water percolating through porous volcanic formations that surround Mt. Shasta and Lassen Peak, which cover much of northeastern California. Chinook salmon require clean loose gravel from 0.75 to 4.0 inches in diameter for successful spawning (NMFS 1997). The construction of dams in the upper Sacramento River has eliminated the major source of suitable gravel recruitment to reaches of the river below Keswick Dam. Gravel sources from the banks of the river and floodplain have also been substantially reduced by levee and bank protection measures. Levee and bank protection measures restrict the meandering of the river, which would normally release gravel into the river through natural erosion and deposition processes. Moyle (2002) reported that water velocity preferences (i.e., suitability greater than 0.5) for Chinook salmon spawning range from 0.98 ft/sec to 2.6 ft/sec (0.3 to 0.8 meters per second (m/sec)) at a depth of a few centimeters (cm) to several meters (m), whereas USFWS (2003) reported that winter-run Chinook salmon prefer water velocities range from 1.54 ft/sec to 4.10 ft/sec (0.47 to 1.25 meters per second) at a depth of 1.4 to 10.1 feet (0.4 to 3.1 m).

Today, Shasta Dam denies access to historical winter-run Chinook salmon spawning habitats and they persist mainly because water released from Shasta Reservoir during the summer has been, for the most part, sufficiently cold. Spawning habitat for Sacramento River winter-run Chinook salmon is restricted to the Sacramento River primarily between RBDD and Keswick Dam.

Embryo Incubation

In the Sacramento River, winter-run Chinook salmon spawning occurs from late April through mid-August. Because the embryo incubation life stage begins with fertilized egg deposition and ends with fry emergence from the gravel, embryo incubation occurs from late April through mid-October. Fry emergence occurs from mid-June through mid-October (NMFS 1997). Within the appropriate water temperature range, eggs normally hatch in 40 to 60 days. Newly hatched fish (alevins) normally remain in the gravel for an additional four to six weeks until the yolk sac has been absorbed (NMFS 1997).

Physical habitat requirements for embryo incubation are the same as the requirements discussed above for spawning. However, it is also important that flow regimes remain relatively constant or at least not decrease significantly during the embryo incubation life stage.

Juvenile Rearing and Outmigration

Upon emergence from the gravel, fry swim or are displaced downstream (Healey 1991). Fry seek streamside habitats containing beneficial aspects such as riparian vegetation and associated substrates that provide aquatic and terrestrial invertebrates for food, predator avoidance cover, and slower water velocities for resting (NMFS 1996a). These shallow water habitats have been described as more productive juvenile salmon rearing habitat than the deeper main river channels. Higher juvenile salmon growth rates, partially due to greater prey consumption rates, as well as favorable environmental temperatures have been associated with shallow water habitats (Sommer *et al.* 2001b). Similar to adult salmon upstream movement, juvenile salmon downstream movement is primarily crepuscular. Once downstream movement has commenced, salmon fry continue this movement until reaching the estuary or they might reside in the stream for a time period that varies from weeks to a year (Healey 1991). Juvenile Chinook salmon migration rates vary considerably, presumably depending on the physiological stage of the juvenile and hydrologic conditions. Kjelson *et al.* (1981) found Chinook salmon fry traveled as fast as 30 kilometers (km) per day in the Sacramento River. Sommer *et al.* (2001b) found travel rates ranging from approximately 0.8 km (0.5 miles) per day, up to more than 9.7 km (6 miles) per day in the Yolo Bypass.

As juvenile Chinook salmon grow they move into deeper water with higher current velocities, but still seek shelter and velocity refugia to minimize energy expenditures (Healey 1991). Catches of juvenile salmon in the Sacramento River near West Sacramento by the USFWS (USFWS 1997) exhibited larger juvenile captures in the main channel and smaller-sized fry along the margins. Where the river channel is greater than nine to ten feet in depth, juvenile salmon tend to inhabit the surface waters (Healey 1979). Streamflow and/or turbidity increases in the upper Sacramento River basin are thought to stimulate emigration (Poytress 2007).

Emigration of juvenile Sacramento River winter-run Chinook salmon past RBDD may begin after almost one year in the river. They begin to move down river as early as mid-July, typically peaking numbers in September, and can continue through March in dry years (NMFS 1997; Vogel and Marine 1991). From 1995 to 1999, all Sacramento River winter-run Chinook salmon outmigrating as fry passed RBDD by October, and all outmigrating pre-smolts and smolts passed RBDD by March (Martin *et al.* 2001).

As Chinook salmon begin the smoltification stage, they are found rearing further downstream where ambient salinity reaches 1.5 to 2.5 parts per thousand (Healey 1979). Within the Delta, juvenile Chinook salmon forage in shallow areas with protective cover, such as tidally influenced sandy beaches and vegetated zones (Healey 1979). Cladocerans, copepods, amphipods, and larvae of diptera, as well as small arachnids and ants are common prey items (Kjelson *et al.* 1981; MacFarlane and Norton 2002; Sommer *et al.* 2001a).

Juvenile Chinook salmon movements within the estuarine habitat are dictated by the interaction between tidally-driven salt water intrusions through the San Francisco Bay and fresh water outflow from the Sacramento and San Joaquin rivers. Juvenile Chinook salmon follow rising tides into shallow water habitats from the deeper main channels and return to the main channels when the tides recede (Healey 1991). Kjelson *et al.* (1981) reported that juvenile Chinook salmon demonstrated a diel migration pattern, orienting themselves to nearshore cover and structure during the day, but moving into more open, offshore waters at night. The fish also distributed themselves vertically in relation to ambient light. During the night, juveniles were distributed randomly in the water column, but would school up during the day into the upper three meters of the water column. Juvenile Chinook salmon were found to spend about 40 days migrating through the Delta to the mouth of San Francisco Bay, and grew little in length or weight until they reached the Gulf of the Farallon Islands (MacFarlane and Norton 2002).

Juvenile Sacramento River winter-run Chinook salmon occur in the Delta primarily from November through early May, using size-at-date criteria from trawl data in the Sacramento River at West Sacramento (RM 57) (USFWS 2001). The timing of migration varies somewhat due to changes in river flows, dam operations, and water year type. Winter-run Chinook salmon juveniles remain in the Delta until they reach a fork length (FL) of approximately 118 millimeters (mm) and are from five to 10 months of age. Emigration to the ocean begins as early as November and continues through May (Fisher 1994; Myers *et al.* 1998). The importance of the Delta in the life history of Sacramento River winter-run Chinook salmon is not well understood.

Central Valley Chinook salmon begin their ocean life in the Gulf of the Farallones, then they distribute north and south along the continental shelf primarily between Point Conception and Point Arena, although some winter-run Chinook salmon migrate up and beyond Washington State. Upon reaching the ocean, juvenile Chinook salmon feed voraciously on larval and juvenile fishes, plankton, and terrestrial insects (Healey 1991; MacFarlane and Norton 2002). Chinook salmon grow rapidly in the ocean environment, with growth rates dependent on water temperatures and food availability (Healey 1991).

2.1.4 Abundance Trends and Distribution

One of the main threats to the Sacramento River winter-run Chinook salmon ESU is that it consists of only one population. Furthermore the one population is small (Good *et al.* 2005). The population declined from an escapement of near 100,000 in the late 1960s to fewer than 200 in the early 1990s (Good *et al.* 2005). More recent population estimates of 8,218 (2004), 15,730 (2005), and 17,153 (2006) show a three-year average of 13,700 returning winter-run Chinook salmon (CDFW Website 2007). However, the run size decreased to 2,542 in 2007 and 2,850 in 2008. **Figure 2-2** depicts the estimated run sizes of Sacramento River winter-run Chinook salmon from 1967 through 2012.

The LSNFH winter-run Chinook salmon conservation program on the upper Sacramento River is one of the most important reasons that Sacramento River winter-run Chinook salmon still persist. The LSNFH has been producing and releasing winter-run Chinook salmon since 1998. This conservation program has apparently resulted in a net increase in the numbers of returning adult winter-run Chinook salmon, although hatchery fish make up a significant portion of the population (Brown and Nichols 2003). Since 2003, LSNFH winter-run program has exceeded best management practices for conservation and recovery of natural salmonid populations.

Table 2-2 shows the annual number of winter-run Chinook salmon released from the facility from 1998 through 2012. The fish are marked with coded wire tags (CWT), adipose fin clipped and released as smolts each winter in late January or early February. The table also provides information based on data acquired during mark-recapture studies on the amount of time required by the smolts to migrate through the Delta.

Winter-run Chinook salmon originally spawned in the upper Sacramento River system (Little Sacramento, Pit, McCloud and Fall rivers) and in Battle Creek (Yoshiyama *et al*. 1996). There is no evidence that the winter-run existed in any of the other drainages prior to watershed development (Yoshiyama *et al.* 1996). The unique life history timing pattern of winter-run Chinook salmon, requiring cold summer flows, argues against this run occurring in drainages other than the upper Sacramento system and Battle Creek. Watershed development has eliminated all historical spawning habitats above Keswick Dam (approximately 200 river miles) and approximately 47 of the 53 miles of potential habitat in Battle Creek (Yoshiyama *et al.* 1996). Figure 2-1 depicts the current and historical distribution of Sacramento River winter-run Chinook salmon.

Currently, winter-run Chinook salmon spawning habitat is likely limited to the reach of the Sacramento River extending from Keswick Dam downstream to the RBDD. Prior to construction of Shasta and Keswick dams, the mainstem Sacramento River primarily functioned as a rearing and migration corridor because warm water temperatures likely precluded spawning. Winter-run Chinook salmon still have access to Battle Creek throughout the duration of their migration period by either passing through the Coleman National Fish Hatchery (CNFH) (December through February) or by ascending the fish ladder located at the CNFH weir (March through July).

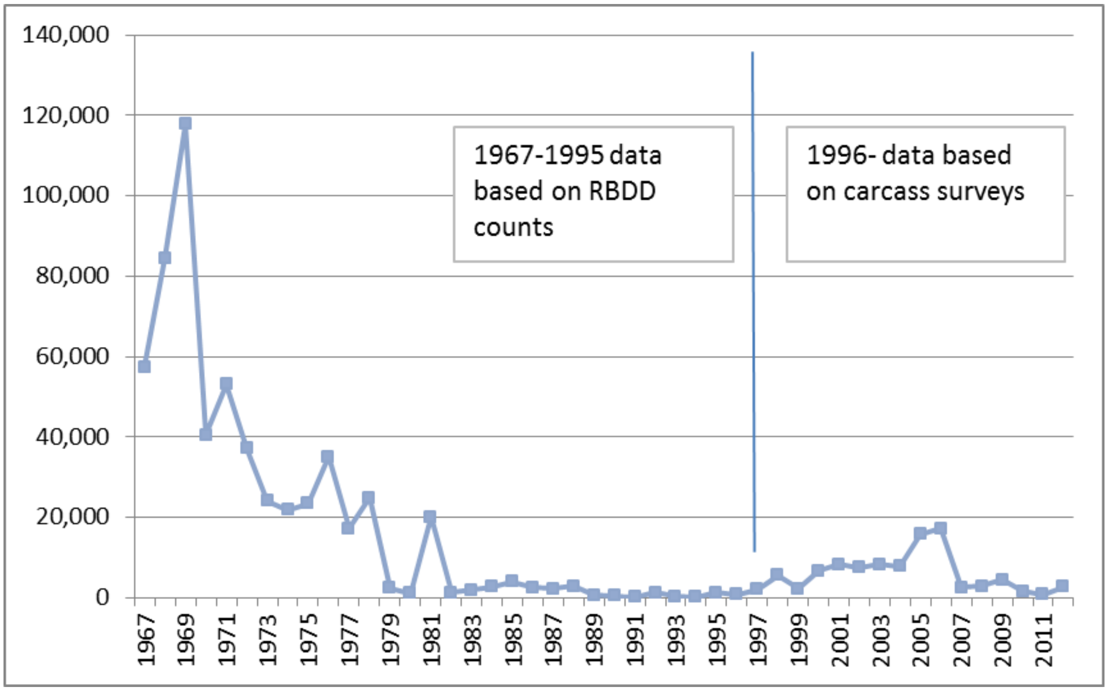


Figure 2-2. Estimated Sacramento River Winter-run Chinook Salmon Run Size (1967 – 2012).
Source: **http://www.fws.gov/stockton/afrp/**

Table 2-2. Winter-run Chinook Salmon Juvenile Releases from LSNFH (Broodyears 1998-2012) and Date of Initial Recapture at Chipps Island.

Brood Year	Upper Sacramento River Release Date	Number of Pre-Smolts Released[1]	Initial Date[2] of Recapture at Chipps Island
1998	1/28/1999	153,908	3/15/1999
1999	1/27/2000	30,840	3/18/2000
2000	2/01/2001	166,206	3/09/2001
2001	1/30/2002	252,684	3/20/2002
2002	1/30/2003	233,613	2/14/2003
2003	2/05/2004	218,617	2/20/2004
2004	2/03/2005	168,261	2/22/2005
2005	2/02/2006	173,344	2/17/2006
2006	2/08/2007	196,288	2/17/2007
2007	1/31/2008	71,883	3/12/2008
2008	1/29/2009	146,211	2/20/2009
2009	2/10-11/2010	198,582	2/26/2010
2010	2/3/2011	123,859	3/21/2011
2011	2/9/2012	194,264	3/23/2012
2012	2/7/2013	181,857	
Source: ([1]USFWS Red Bluff; [2] Redler 2013)			

Winter-run Chinook salmon are believed to have historically occurred in Battle Creek as one of four independent Central Valley populations (Lindley *et al.* 2004). Hydroelectric facilities and operations likely caused the extirpation of winter-run Chinook salmon from the Battle Creek watershed in the early 1900s (Reynolds *et al.* 1993). Watershed restoration actions associated with the Battle Creek Salmon and Steelhead Restoration Project are expected to restore conditions that will allow for successful reintroduction of winter-run Chinook salmon to Battle Creek.

The USFWS initiated the winter-run Chinook salmon propagation program at the CNFH in 1989. Although the winter-run Chinook salmon propagation program was located on Battle Creek, the program had the goal of supplementing natural spawning in the mainstem of the upper Sacramento River. To encourage adults to return to the Sacramento River rather than the location of the hatchery on Battle Creek, hatchery-produced juvenile winter-run Chinook salmon were released into the mainstem Sacramento River at the pre-smolt life stage. Unfortunately, this strategy was not successful at achieving a successful imprint to the upper Sacramento River and adults instead returned to the location of the hatchery on Battle Creek. To improve imprinting to the upper Sacramento River, the winter-run Chinook salmon propagation program was moved in 1997 to a new facility, the LSNFH, located immediately downstream of Shasta Dam. Within a few years of relocating the winter-run Chinook salmon propagation program, returns of adult winter-run Chinook salmon to Battle Creek declined to zero. During recent years, a few winter-run Chinook salmon adults have been observed in Battle Creek; these fish are likely strays from the mainstem Sacramento River.

A winter-run Chinook salmon migration to the Calaveras River may have occurred between 1972 and 1984, but this population appears to have been extirpated by drought conditions, which were exacerbated by irrigation diversions (NMFS 1997; NMFS 1999; NMFS 2003). This Calaveras River population is also thought to have been late fall-run or fall-run Chinook salmon that were mistakenly identified as winter-run Chinook salmon (Yoshiyama *et al.* 2000). Winter-run Chinook salmon did not historically occur in the Calaveras River because the natural river conditions were not suitable to support the species life history requirements (e.g., cold water during the spring and summer for holding, spawning, and embryo incubation).

The Sacramento River winter-run Chinook salmon population is dependent upon the provision of suitably cool water temperatures during the spawning, embryo incubation, and juvenile rearing period. Water temperatures in the upper Sacramento River are the result of interaction among: (1) ambient air temperature; (2) volume of water; (3) water temperature at release from Shasta and Trinity dams; (4) total reservoir storage; (5) location of reservoir thermocline; (6) ratio of Spring Creek Power Plant release to Shasta Dam release; (7) operation of Temperature Control Device (TCD) on Shasta Dam; and (8) tributary inflows (NMFS 1997). Water temperature varies with location and distance downstream of Keswick Dam, and depends upon the annual hydrologic conditions and annual operation of the Shasta-Trinity Division of the CVP (NMFS 1997). In general, water released from Keswick Dam warms as it moves downstream during the summer and early fall months at a critical time for the successful development and survival of juvenile winter-run Chinook salmon (NMFS 1997).

2.1.5 Critical Habitat

Critical habitat for listed salmonids is comprised of physical and biological features essential to the conservation of the species including: space for the individual and population growth and for normal behavior; cover; sites for breeding, reproduction and rearing of offspring; and habitats protected from disturbance or are representative of the historical geographical and ecological distribution of the species. Physical and biological features that are essential for the conservation of winter-run Chinook salmon, based on the best available information, include (1) access from the Pacific Ocean to appropriate spawning areas in the upper Sacramento River; (2) the availability of clean gravel for spawning substrate; (3) adequate river flows for successful spawning, incubation of eggs, fry development and emergence, and downstream transport of juveniles; (4) water temperatures between 42.5 and 57.5 °F (5.8 and 14.1 degrees Celsius (°C)) for successful spawning, egg incubation, and fry development; (5) habitat and adequate prey free of contaminants; (6) riparian habitat that provides for successful juvenile development and survival; and (7) access of juveniles downstream from the spawning grounds to San Francisco Bay and the Pacific Ocean (58 FR 33212, 33216-17; June 16, 1993).

On August 14, 1992, NMFS published a proposed critical habitat designation for winter-run Chinook salmon (57 FR 36626). The habitat proposed for designation included: (1) the Sacramento River from Keswick Dam, Shasta County (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta; (2) all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; (3) all waters of San Pablo Bay westward of the Carquinez Bridge; and (4) all waters of San Francisco Bay to the Golden Gate Bridge (NMFS 1997).

On June 16, 1993, NMFS issued the final rule designating critical habitat for winter-run Chinook salmon (58 FR 33212). The habitat identified in the final designation is identical to that in the proposed ruling except that critical habitat in San Francisco Bay is limited to those waters north of the San Francisco-Oakland Bay Bridge. **Figure 2-3** depicts the designated critical habitat and distribution for Sacramento River winter-run Chinook salmon.

2.1.6 Reasons for Listing

Section 4 of the ESA requires the Secretary of the Interior or Commerce, depending upon the species involved, to determine if any species is an endangered or threatened species for any of the following factors: (1) present or threatened destruction, modification or curtailment of its habitat or range; (2) overutilization for commercial, recreational, scientific or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence. Each of these factors with respect to winter-run Chinook salmon are discussed in detail in past status reviews (52 FR 6041, February 27, 1987; Good *et al.* 2005; NMFS 2011) and are summarized below.

The Present or Threatened Destruction, Modification, or Curtailment of Winter-run Chinook Salmon's Habitat or Range.

<u>Habitat Loss and Degradation</u>

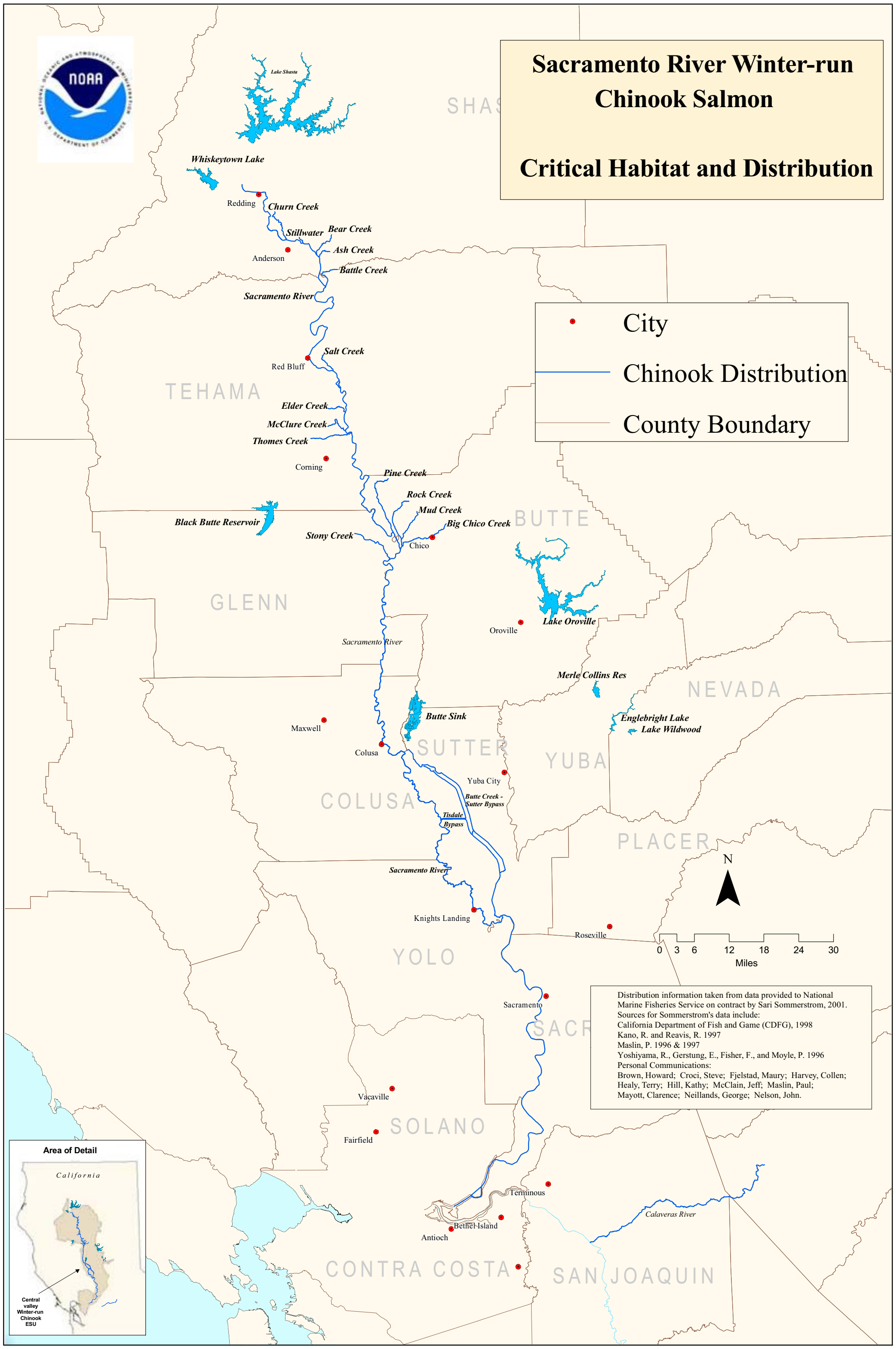
Key reasons why winter-run Chinook salmon were listed under the ESA in 1989 include blockage of historical habitat by Shasta and Keswick dams, warm water releases from

Shasta Dam, juvenile and adult passage constraints at RBDD and Anderson-Cottonwood Irrigation District's (ACID) diversion dam, water exports in the southern Delta, loss of rearing habitat, heavy metal contamination from Iron Mountain Mine, and entrainment in a large number of unscreened or poorly screened water diversions (NMFS 1997). Since winter-run Chinook salmon were listed, the passage problems at RBDD and ACID's dam have been addressed and contamination from Iron Mountain Mine has been contained. Additionally, water temperature management has improved since the time when the ESU was listed, although warm water temperatures in the Sacramento River downstream of Keswick Dam remain a concern, particularly in drier years.

A Single Population

The range of winter-run Chinook salmon has been greatly reduced by Keswick and Shasta dams on the Sacramento River and by hydroelectric development on Battle Creek. Currently, winter-run Chinook salmon spawning is limited to the mainstem Sacramento River downstream of Shasta and Keswick dams where the naturally-spawning population is artificially maintained by cool water releases from the dams. Within the Sacramento River, the spatial distribution of spawners is largely governed by water year type and the ability of the CVP to manage water temperatures.

The fact that this ESU is comprised of a single population with very limited spawning and rearing habitat increases its risk of extinction due to local catastrophe or poor environmental conditions. There are no other natural populations in the ESU to buffer it from natural fluctuations. A single catastrophe with effects persisting for four or more years could result in extinction of the Sacramento River winter-run Chinook salmon ESU (Lindley *et al.* 2007). Such potential catastrophes include volcanic eruption of Lassen Peak, prolonged drought which depletes the cold water pool in Shasta Reservoir or some related failure to manage cold water storage, a spill of toxic materials with effects that persist for four years, or a disease outbreak.



Distribution information taken from data provided to National Marine Fisheries Service on contract by Sari Sommerstrom, 2001.
Sources for Sommerstrom's data include:
California Department of Fish and Game (CDFG), 1998
Kano, R. and Reavis, R. 1997
Maslin, P. 1996 & 1997
Yoshiyama, R., Gerstung, E., Fisher, F., and Moyle, P. 1996
Personal Communications:
Brown, Howard; Croci, Steve; Fjelstad, Maury; Harvey, Collen; Healy, Terry; Hill, Kathy; McClain, Jeff; Maslin, Paul; Mayott, Clarence; Neillands, George; Nelson, John.

Figure 2-3. Sacramento River Winter-run Chinook Salmon Designated Critical Habitat and Distribution

After two years of drought, Shasta Reservoir storage would be insufficient to provide cold water throughout the winter-run Chinook salmon spawning and embryo incubation season, resulting in partial or complete year-class failure. A severe drought lasting more than 3 years would likely result in the extinction of winter-run Chinook salmon. The probability of extended droughts is increasing as the effects of climate change continue (see Chapter 6).

An ESU that is represented by a single population is less able to withstand environmental variation than an ESU with multiple populations because of reduced life history and genetic diversity. The genetic integrity of winter-run Chinook salmon has been compromised due to having passed through several "bottlenecks" in the 20th century. Construction of Shasta Dam merged at least three independent winter-run Chinook populations into a single population, representing a substantial loss of genetic diversity, life history variability, and local adaptation. Episodes of critically low abundance, particularly in the early 1990s, for the single remaining population imposed ‘‘bottlenecks’’ that further reduced genetic diversity (Good *et al.* 2005).

Small Population Size

Chief among the threats facing winter-run Chinook salmon is small population size—escapement fell below 200 fish in the 1990s. In 1989, the CDFW estimated that the winter-run Chinook salmon size was only 547 fish. This unexpectedly small return represented nearly a 75 percent decline from the consistent, but low, run size of 2,000 to 3,000 fish that had occurred since 1982. The run size estimate made by the CDFW for 1991 was 191 fish. Population size declined from highs of near 100,000 fish in the late 1960s, indicating a sustained period of poor survival (Good *et al.* 2005).

Overutilization of Winter-Run Chinook Salmon for Commercial, Recreational, Scientific, or Educational Purposes

Commercial and Recreational Fisheries

When the winter-run Chinook salmon ESU was being evaluated by NMFS for listing under the ESA in the late 1980s, overutilization was not considered to be an important factor in the species decline. A winter-run Chinook salmon status review published in 1987 stated: "NMFS believes that any stock (even marginally healthy one) should be able to maintain stable population levels at the moderate harvest levels to which winter-run chinook are subjected and that harvests have not been instrumental in the decline of winter-run chinook in the Sacramento River" (52 FR 6041, 6045; February 27, 1987). Two years later when the emergency rule to list winter-run Chinook salmon was published, overutilization was still considered unimportant; the primary reasons for the species decline were identified as the construction and operation of RBDD and other human activities that had degraded spawning and rearing habitat in the Sacramento River (54 FR 32085; August 4, 1989).

In the years following the ESA listing of winter-run Chinook salmon, more information on the impacts of the ocean fisheries on the ESU became available, and it was recognized that the fisheries may play a greater role in the viability of the ESU than previously thought. In 1996 and 1997 NMFS issued a biological opinion and amendment which considered the effects of ocean salmon fisheries on winter Chinook salmon. Those documents determined that the ocean fisheries jeopardize winter-run Chinook salmon and, as part of the reasonable and prudent alternative, fishery restrictions were adopted to protect the ESU.

There have been five biological opinions issued for the ocean salmon fishery's effects on winter-run (1991, 1996/1997, 2002, 2004, and 2010). Similar to the 1996/1997 biological opinion, the 2010 biological opinion determined that the fisheries jeopardized the species. To avoid jeopardy, the action agency (NMFS Sustainable Fisheries Division) continues to implement the reasonable and prudent alternative, which: (1) specifies that the previous consultation standards for winter-run Chinook salmon regarding minimum size limits and seasonal windows south of Point Arena for both the commercial and recreational fisheries will continue to remain in effect at all times regardless of abundance estimates or impact rate limit; and (2) establishes an abundance-based management framework where, during periods of relatively low abundance, the fisheries are restricted in order to lower the impact rate on winter-run Chinook salmon.

Based on data from 1968-73 and 1975, Hallock and Fisher (1985) reported that the freshwater sport fishery harvested an average of 8.5 percent of the in-river run. Freshwater harvest of winter-run Chinook salmon was largely eliminated in 2002 when the opening of the Sacramento River recreational fishing season was adjusted so that the fishery would have only limited overlap with the adult immigration and spawning life stages.

Disease or Predation

Disease

Disease was not an important factor in the listing of winter-run Chinook salmon (52 FR 6041, 6045; February 27, 1987) and the impact of disease has probably been negligible since then. There is no evidence that winter-run Chinook salmon experience unusual levels of disease. Winter-run Chinook salmon juveniles from LSNFH have been notably healthy and free of disease problems. There have been no outbreaks of Infectious Hematopoietic Necrosis Virus or Bacterial Kidney Disease at LSNFH (USFWS 2011).

Predation

Predation is an ongoing threat to this ESU, especially in the lower Sacramento River and Delta where there are high densities of non-native (i.e., striped bass, smallmouth bass, and largemouth bass) and native species (e.g., pikeminnow) that prey on outmigrating juvenile salmon. The presence of man-made structures in the freshwater habitat likely contributes to increased predation levels. Since the 1970s, RBDD has been an area of high salmon predation, primarily by pikeminnow (Vogel 2011). Numerous corrective measures at RBDD have been taken over the last few decades to reduce predation. Since 2012, the dam is no longer operated with the gates in. This operational change should greatly reduce predation on juvenile salmon at RBDD.

Degraded conditions in the lower Sacramento River and Delta are a significant source of mortality for Chinook salmon (Cummins *et al.* 2009; Vogel 2011). Predation is hypothesized to be an important source of this mortality (Cummins *et al.* 2009; Vogel 2011; Moyle 2002). Moyle (2002) states, "*What we do not know is whether these species [native species], now mostly depleted, can recover their populations in the presence of a large population of striped bass…A large population of striped bass, for example, could devastate a small population of salmon.*" Consistent with Moyle (2002), a predation model developed by Lindley and Mohr (2003) found that a large striped bass population may impede winter-run Chinook salmon recovery.

The Inadequacy of Existing Regulatory Mechanisms

Laws relevant to the protection and restoration of winter-run Chinook salmon are the ESA, the Magnuson-Stevens Fishery Conservation and Management Act, the CVPIA, the Federal Power Act, the Fish and Wildlife Coordination Act, the Clean Water Act, the National Environmental Policy Act, and numerous State laws administered by CDFW, DWR, or the SWRCB. These laws and associated regulations generally provide adequate mechanisms for recovering winter-run Chinook salmon (52 FR 6041, 6046; February 27, 1987); however some of the goals of these existing mechanisms have not yet been achieved.

Other Natural or Manmade Factors Affecting the Continued Existence of Winter-Run Chinook Salmon

Hatchery Production

Although the LSNFH winter-run Chinook salmon program is one of the most important reasons that the species still persists, the use of a hatchery program to supplement the population raises concerns about the genetic integrity and fitness of the population. There is a strong perception that hatchery fish may negatively affect the genetic constitution of wild fish (Allendorf *et al.* 1997; Hindar *et al.* 1991; Waples 1991). One of the main factors contributing to this perception is the observation of a reduction in wild fish populations following the initiation of a hatchery release program (Hilborn 1992; Washington and Koziol 1993). An explanation offered for this observation is that hatchery fish are adapted to the hatchery environment; therefore, natural spawning with wild fish reduces the fitness of the natural population (Taylor 1991). Researchers from the University of California at Davis have documented that hatchery Chinook salmon were more vulnerable to predation by Sacramento pikeminnow as they pass RBDD than were wild Chinook salmon (Lufkin 1996). To minimize hatchery effects in the population, LSNFH preferentially collects wild winter-run Chinook salmon adults for the program. A maximum of 15 percent of the estimated winter-run Chinook salmon run, but no more than 120 natural-origin winter-run Chinook salmon per broodyear may be collected for broodstock use. If necessary, up to 10 percent (a maximum of 12 fish) of the LSNFH broodstock may be composed of hatchery adult returns. To ensure that hatchery production does not overwhelm the recovering population, annual hatchery releases are kept within the 200,000 to 250,000 range and the effects of the program are well-monitored.

The rising proportion of hatchery fish among returning adults threatens to shift the population from a low to moderate risk of extinction. Lindley *et al.* (2007) recommend that in order to maintain a low risk of genetic introgression with hatchery fish, no more than five percent of the naturally-spawning population should be composed of hatchery fish. Since 2001, hatchery origin winter-run Chinook salmon have made up more than five percent of the run, and in 2005 the contribution of hatchery fish exceeded 18 percent (Lindley *et al.* 2007). Potential consequences to wild fish stocks from hatchery production include hybridization and genetic introgression, competition, predation, and increasing fishing pressure (Waples 1991).

Because LSNFH is a conservation hatchery using best management practices, a more appropriate tool to determine associated genetic risk may be the Proportionate Natural Influence (PNI). PNI is an index of gene flow rates between hatchery and natural populations that can be calculated by using the following formula:

$$PNI\ Approx = pNOB/(pNOB+pHOS)$$

Where pNOB is defined as the Proportion of Natural Origin Brood Stock, and pHOS as the Proportion of Hatchery Origin In-River Spawners.

The Hatchery Scientific Review Group (HSRG), an independent scientific review panel for the Pacific Northwest Hatchery Reform Project, developed guidelines as minimal requirements for minimizing genetic risks of hatchery programs to naturally spawning populations. One of those guidelines is that PNI must exceed 0.5 in order for the natural environment to have a greater influence than the hatchery environment on the genetic constitution of a naturally-spawning population. A second guideline is that PNI should be greater than 0.67 for natural populations considered essential for the recovery or viability of an ESU/DPS.

The average PNI for LSNFH winter-run Chinook salmon from 2003 through 2012 is 0.89 (Null 2013); a level which satisfies the HSRG guidelines for minimizing the genetic effects of hatchery programs on natural populations.

In summary, LSNFH is one of the most important reasons that Sacramento River winter-run Chinook salmon still persist and the hatchery is considered beneficial to the ESU over the short term. However, if the continued existence of the ESU depends on LSNFH, it by any reasonable definition cannot be characterized as having a low risk of extinction, and therefore the ESU should not be delisted on that basis. If the status of the ESU improves such that it has a high likelihood of persistence without LSNFH, then the LSNFH winter-run Chinook program should be phased out and eventually terminated. To obtain long-term sustainability, ESUs need to have some low-risk populations with essentially no hatchery influence in the long run; they could have additional populations with some small hatchery influence, but there needs to be a core of populations that are not dependent on hatchery production.

2.1.7. Threats Assessment

A detailed threats assessment was conducted for the Sacramento River winter-run Chinook salmon ESU (Appendix B). The threats/stressors affecting each winter-run Chinook salmon life stage are described in that appendix. A stressor matrix[3], in the form of a single Microsoft Excel worksheet, was developed to structure the winter-run Chinook salmon population, life stage, and stressor information into hierarchically-related tiers so that stressors to the ESU could be prioritized. The individual tiers within the matrix, from highest to lowest, are: (1) population; (2) life stage; (3) primary stressor category; and (4) specific stressor. These individual tiers were related hierarchically so that each variable within a tier had several associated variables at the next lower tier, except at the lowest (i.e., fourth) tier.

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[3] For winter-run Chinook salmon, a single stressor matrix was developed corresponding to the mainstem upper Sacramento River population, whereas for spring-run Chinook salmon and steelhead, multiple individual stressor matrices were developed corresponding to each of the extant populations for these species.

The general steps required to develop and utilize the winter-run Chinook salmon stressor matrix are described as follows:

- ❑ Each life stage within the population was weighted so that all life stage weights in the population summed to one
- ❑ Each primary stressor category within a life stage was weighted so that all primary stressor category weights in a life stage summed to one
- ❑ Each specific stressor within a primary stressor category was weighted so that all specific stressor weights in a primary stressor category summed to one
- ❑ A composite weight for each specific stressor was obtained by multiplying the product of the population weight, the life stage weight, the primary stressor weight, and the specific stressor weight by 100
- ❑ A normalized weight for each specific stressor was obtained by multiplying the composite weight by the number of specific stressors within a particular primary stressor group
- ❑ The stressor matrix was sorted by the normalized weight of the specific stressors in descending order

Specific information explaining the individual steps taken to generate this prioritized list are provided in Appendix B.

The completed stressor matrix sorted by normalized weight is a prioritized list of the life stage-specific stressors affecting the ESU. Each life stage of winter-run Chinook salmon is affected by stressors of "Very High" importance. These stressors include:

- ❑ The barriers of Keswick and Shasta dams, which block access to historic staging and spawning habitat
- ❑ Flow fluctuations, water pollution, water temperature impacts in the upper Sacramento River during embryo incubation
- ❑ Loss of juvenile rearing habitat in the form of lost natural river morphology and function, and lost riparian habitat and instream cover
- ❑ Predation during juvenile rearing and outmigration
- ❑ Ocean harvest
- ❑ Entrainment of juveniles at the C.W. Jones and Harvey O. Banks pumping plants

The complete prioritized list of life stage-specific stressors to the Sacramento River winter-run Chinook salmon ESU is presented in Appendix B.

2.1.8 Conservation Measures

Artificial Propagation

Captive broodstock and conservation hatchery programs were established for the Sacramento River winter-run Chinook salmon ESU in the early 1990s. The captive broodstock program was originally located at the Bodega Marine Laboratory and the hatchery program was initially established at the CNFH and then later re-located to the LSNFH. These programs were established to augment the naturally spawning population in the Sacramento River as well as to provide a captive broodstock in case the natural population was unexpectedly decimated. The programs were successful in helping to stop winter-run Chinook salmon from going extinct. The captive broodstock program was discontinued in January 2005 and the final captive broodstock fish were utilized for a research study in 2006. The LSNFH winter-run Chinook salmon hatchery program continues to supplement the natural population while minimizing genetic risks.

LSNFH is expected to play a continuing role as a conservation hatchery for the protection and enhancement of the existing winter-run Chinook salmon population below Keswick and Shasta dams, and potentially will play a role in re-establishing winter-run salmon to habitats upstream of Shasta Dam and to Battle Creek.

Endangered Species Act

Actions taken by Reclamation and DWR to ensure that their operations of the CVP and SWP comply with Section 7 of the ESA likely contributed to habitat improvements benefiting the Sacramento River winter-run Chinook salmon ESU. Implementation of the reasonable and prudent alternative in biological opinions for the CVP and SWP has improved fish habitat and passage conditions in the Sacramento River and the Delta through maintenance of minimum water flows during fall and winter months, establishment of temperature criteria to support spawning and rearing upstream of RBDD (coupled with water releases from Shasta Dam), operation of the RBDD gates for improved adult and juvenile fish passage, and constraints on Delta water exports to reduce impacts on juvenile outmigrants.

Ecosystem Restoration Program

Two large, ongoing comprehensive conservation programs in the Central Valley provide a wide range of ecosystem and species-specific protective efforts potentially benefiting Chinook salmon – the State's ERP (formerly the CALFED Bay/Delta Program) and the CVPIA. CALFED was a cooperative effort of more than 20 State and Federal agencies working with local communities to improve water quality and reliability for California's water supplies, and has made efforts to restore the Bay/Delta. The ERP has funded projects involving habitat restoration, floodplain restoration and protection, instream and riparian habitat restoration and protection, fish screening and passage, research on non-native species and contaminants, research and monitoring of fishery resources, and watershed stewardship and outreach. A full description of ERP projects and achievements is available at http://www.dfg.ca.gov/ERP/. A few ERP accomplishments that improved salmon and steelhead habitat include:

- restoration and protection of 8,000 acres of wetlands in San Pablo Bay and Suisun Marsh;
- protection of more than 11,000 acres and 18 river miles for riparian and shaded-riverine-aquatic habitat;
- restoration of more than 3,900 acres and 59 miles of riparian and riverine aquatic habitat; and
- installation or improvement of 70 fish screens (11 that draw >250 cfs).

Overall, the ERP has been a beneficial program for winter-run Chinook salmon. Continued implementation of stage two of ERP, which runs through the year 2030, will be needed to advance winter-run Chinook salmon recovery.

CALFED also established the Environmental Water Account (EWA) to protect migratory fish from entrainment and to increase water supply reliability for the SWP and CVP. A review of the success of EWA revealed that the benefit to salmon is unclear (White and Brandes 2004).

Central Valley Project Improvement Act

The CVPIA balances the priorities of fish and wildlife protection, restoration, and mitigation with irrigation, domestic water use, fish and wildlife enhancement, and power augmentation. The CVPIA was enacted in 1992 with a mandated goal of doubling the natural production of anadromous fish, including winter-run Chinook salmon. Reclamation and USFWS have conducted studies and implemented hundreds of actions, including modifications of CVP operations, management and acquisition of water for fish and wildlife needs, flow management for fish migration and passage, increased water flows, replenishment of spawning gravels, restoration of riparian habitats, and screening of water diversions. Individual actions implemented under the CVPIA that have improved conditions for winter-run Chinook salmon include:

- Installing and operating the Shasta Temperature Control Device;
- Improved and continued efforts for passage at RBDD;
- Completion of state-of-the-art screen and passage improvements at the diversions for the Glen-Colusa Irrigation District and Anderson-Cottonwood Irrigation District; and
- Screening most of the larger diversions in the system (Cummins *et al.* 2009).

An independent review of the CVPIA Fisheries Program identified several successes of the program, but ultimately concluded that, "*After 16 years of implementation the CVPIA anadromous fish program is not close to its stated doubling goal, nor has it solved the problems that led to the listing of several species of salmon and steelhead under the ESA* (Cummins *et al*. 2009)."

Fisheries Management Measures

Seasonal time/area restrictions and minimum size limits for the sport and commercial ocean salmon fisheries are in place for the protection of winter-run Chinook salmon. Additionally, there is a regulatory management framework to further reduce ocean fishery impacts when the status of winter-run is declining or unfavorable (NMFS 2012a). The State has established specific in-river fishing regulations and no-retention prohibitions designed to protect winter-run Chinook salmon during their freshwater life stages.

2.2 Spring-run Chinook Salmon

2.2.1 ESA Listing Status

Central Valley spring-run Chinook salmon (*O. tshawytscha*), currently listed as threatened, were proposed as endangered by NMFS on March 9, 1998 (63 FR 11482). NMFS (1998) concluded that the Central Valley spring-run Chinook salmon ESU was in danger of extinction because native spring-run Chinook salmon have been extirpated from all tributaries in the San Joaquin River Basin, which represented a large portion of the historic range and abundance of the ESU as a whole. Moreover, the only streams considered to have wild spring-run Chinook salmon at that time were Mill and Deer creeks, and Butte Creek (tributaries to the Sacramento River). These populations were considered relatively small with sharply declining trends.

Hence, demographic and genetic risks due to small population sizes were considered to be high. NMFS (NMFS 1998) also determined that habitat problems were the most important source of ongoing risk to this ESU.

On September 16, 1999, NMFS listed the Central Valley ESU of spring-run Chinook salmon as a “threatened” species (64 FR 50394). Although in the original Chinook salmon status review and proposed listing it was concluded that the Central Valley spring-run Chinook salmon ESU was in danger of extinction (Myers *et al.* 1998), in the status review update, the Biological Review Team (BRT) majority shifted to the view that this ESU was not in danger of extinction, but was likely to become endangered in the foreseeable future. A major reason for this shift was data indicating that a large run of spring-run Chinook salmon on Butte Creek in 1998 was naturally produced, rather than strays from the Feather River Fish Hatchery (FRFH).

NMFS determined that the Central Valley spring-run Chinook salmon ESU is likely to become endangered in the foreseeable future throughout all or a significant portion of their range after reviewing the best available information, including public and peer review comments, biological data on the species’ status, and an assessment of protective efforts (64 FR 50394). On March 11, 2002, pursuant to a January 9, 2002 rule issued by NMFS under Section 4(d) of the ESA (16 USC § 1533(d)), the take restrictions that apply statutorily to endangered species began to apply with specific limitations to the Central Valley ESU of spring-run Chinook salmon (67 FR 1116). On June 14, 2004, following a five-year species status review, NMFS proposed that the Central Valley spring-run Chinook salmon remain a threatened species based on the BRT strong majority opinion that the Central Valley spring-run Chinook ESU is ‘‘likely to become endangered within the foreseeable future’’ (69 FR 33102). The BRT based its conclusions on the greatly reduced distribution of the Central Valley spring-run Chinook ESU and hatchery influences on natural populations. In addition, the BRT noted moderately high risk for the abundance, spatial structure, and diversity Viable Salmonid Population (VSP) criteria, and a lower risk for the productivity criterion reflecting positive trends. On June 28, 2005, NMFS reaffirmed the threatened status of the Central Valley spring-run Chinook salmon ESU (70 FR 37160). **Figure 2-4** depicts the Central Valley spring-run Chinook salmon ESU.

2.2.2 Species Description and Taxonomy

The Chinook salmon, also largely referred to as king salmon in California, are the largest of the Pacific salmon. The following physical description of the species is provided by Moyle (2002). Spawning adults are olive to dark maroon in color, without conspicuous streaking or blotches on the sides. Spawning males are darker than females, and have a hooked jaw and slightly humped back. There are numerous small black spots in both sexes on the back, dorsal fins, and both lobes of the tail. They can be distinguished from other spawning salmon by the color pattern, particularly the spotting on the back and tail, and by the dark, solid black gums of the lower jaw. Parr have 6 to 12 parr marks, each equal to or wider than the spaces between them and most centered on the lateral line. The adipose fin of parr is pigmented on the upper edge, but clear at its base. The dorsal fin occasionally has one or more spots on it but the other fins are clear.

2.2.3 Life History/Habitat Requirements

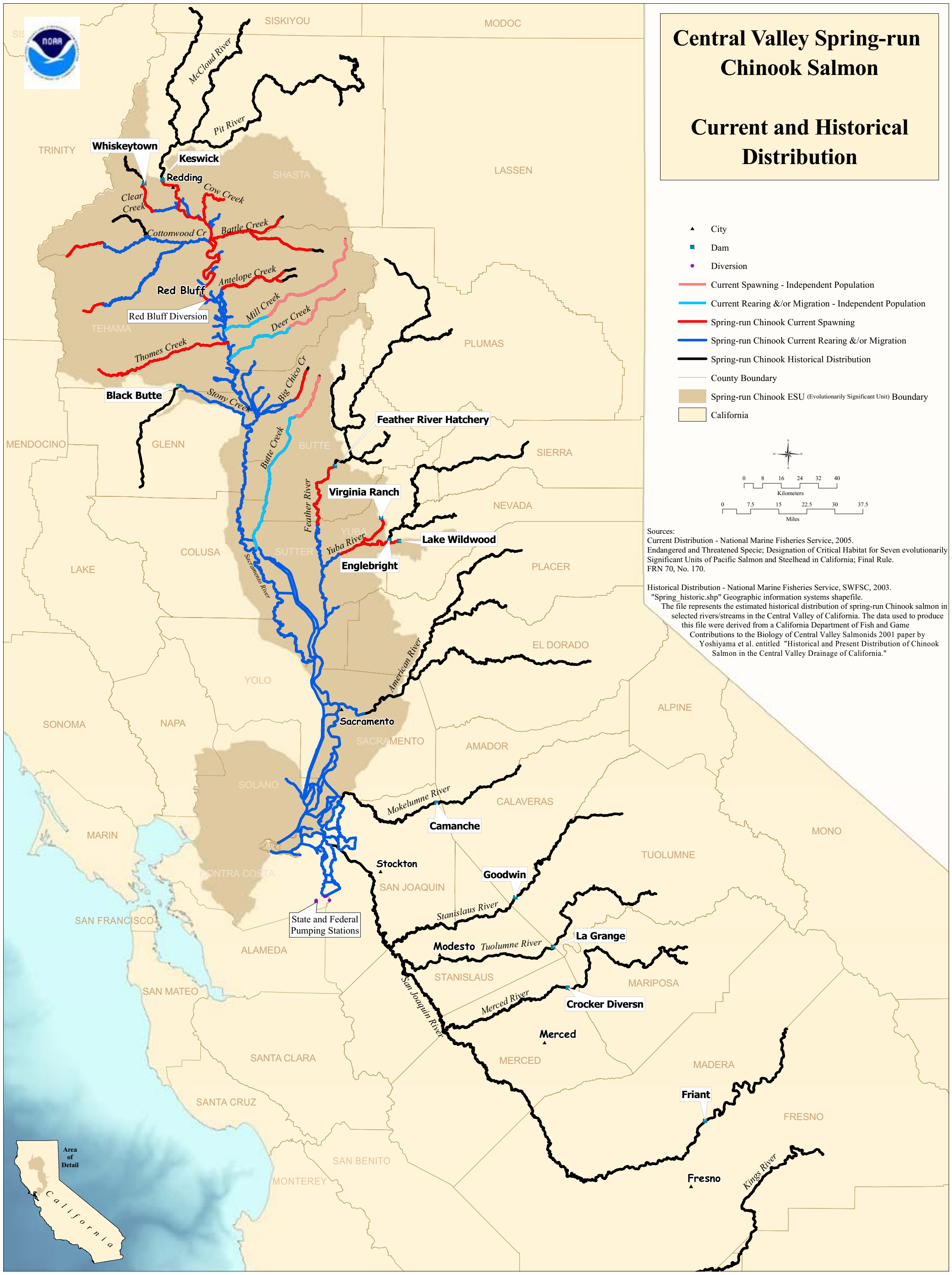
The habitat requirements for spring-run Chinook salmon are the same as those described above for winter-run Chinook salmon. The primary differences in the habitat requirements between the two runs are the duration and the time of year that the different life stages of the species utilize the habitat.

Adult Central Valley spring-run Chinook salmon leave the ocean to begin their upstream migration in late January and early February (CDFW 1998), and enter the Sacramento River between March and September, primarily in May and June (Moyle 2002; Yoshiyama *et al.* 1998). Spring-run Chinook salmon generally enter rivers as sexually immature fish and must hold in freshwater for up to several months before spawning (Moyle 2002). While maturing, adults hold in deep pools with cold water. Spawning normally occurs between mid-August and early October, peaking in September (Moyle 2002).

The length of time required for embryo incubation and emergence from the gravel is dependent on water temperature. For maximum embryo survival, water temperatures reportedly must be between 41°F and 55.4°F and oxygen saturation levels must be close to maximum (Moyle 2002).

Under those conditions, embryos hatch in 40 to 60 days and remain in the gravel as alevins (the life stage between hatching and egg sack absorption) for another 4 to 6 weeks before emerging as fry (Moyle 2002).

Spring-run fry emerge from the gravel from November to March (Moyle 2002). Juveniles may reside in freshwater for 12 to 16 months, but some migrate to the ocean as young-of-the-year in the winter or spring months within eight months of hatching (CALFED 2000b). The average size of fry migrants (approximately 40 mm between December and April in Mill, Butte, and Deer creeks) reflects a prolonged emergence of fry from the gravel (Lindley *et al.* 2004). By contrast, studies in Butte Creek (Ward *et al.* 2003) found the majority of spring-run migrants to be fry moving downstream primarily during December, January, and February, and that these movements appeared to be influenced by flow. Small numbers of spring-run juveniles remained in Butte Creek to rear and migrate as yearlings later in the spring. Juvenile emigration patterns in Mill and Deer creeks are very similar to patterns observed in Butte Creek, with the exception that Mill and Deer creek juveniles typically exhibit a later young-of-the-year migration and an earlier yearling migration (Lindley *et al.* 2004). By contrast, data collected on the Feather River suggests that the bulk of juvenile emigration occurs during November and December (DWR and Reclamation 1999; Painter *et al.* 1977). Seesholtz *et al.* (2003) speculate that because juvenile rearing habitat in the Low Flow Channel of the Feather River is limited, juveniles may be forced to emigrate from the area early due to competition for resources. **Table 2-3** depicts the temporal occurrence of spring-run life stages in the Sacramento River.



Sources:
Current Distribution - National Marine Fisheries Service, 2005.
Endangered and Threatened Specie; Designation of Critical Habitat for Seven evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule.
FRN 70, No. 170.

Historical Distribution - National Marine Fisheries Service, SWFSC, 2003.
"Spring_historic.shp" Geographic information systems shapefile.
The file represents the estimated historical distribution of spring-run Chinook salmon in selected rivers/streams in the Central Valley of California. The data used to produce this file were derived from a California Department of Fish and Game Contributions to the Biology of Central Valley Salmonids 2001 paper by Yoshiyama et al. entitled "Historical and Present Distribution of Chinook Salmon in the Central Valley Drainage of California."

Figure 2-4. Central Valley Spring-run Chinook Salmon ESU, and Current and Historical Distribution.

2.2.4 Abundance Trends and Distribution

Historically, spring-run Chinook salmon occurred in the headwaters of all major river systems in the Central Valley where natural barriers to migration were absent.

The Central Valley as a whole is estimated to have supported spring-run Chinook salmon runs as large as 600,000 fish between the late 1880s and 1940s (CDFW 1998). More than 500,000 Central Valley spring-run Chinook salmon were caught in the Sacramento-San Joaquin commercial fishery in 1883 (Yoshiyama *et al.* 1998).

Although spring-run Chinook salmon were probably the most abundant salmonid in the Central Valley under historic conditions, large dams eliminated access to almost all historical habitat and the spring-run has suffered the most severe declines of any of the four Chinook salmon runs in the Sacramento River Basin (Fisher 1994).

Beginning in the 1880s, harvest, water development, construction of dams that prevented access to headwater areas and habitat degradation significantly reduced the number and range of spring-run Chinook salmon.

Before construction of Friant Dam, nearly 50,000 adults were counted in the San Joaquin River (Fry 1961). The San Joaquin populations essentially were extirpated by the 1940s, with only small remnants of the run persisting through the 1950s in the Merced River (Yoshiyama *et al.* 1998). From 1970 through 2012, Central Valley spring-run Chinook salmon run size estimates have fluctuated from highs near 30,000 to lows near 3,000 (**Figure 2-5**).

The only known streams that currently support self-sustaining populations of non-hybridized spring-run Chinook salmon in the Central Valley are Mill, Deer and Butte creeks (CDFW 1998). Each of these populations is small and isolated. **Figure 2-6** depicts the annual run size estimates for these populations. These populations are genetically distinct from other populations classified as spring-run in the Central Valley (e.g., Feather River) (DWR 2004a). Banks *et al.* (2000) suggest the spring-run phenotype in the Central Valley is shown by two genetically distinct subpopulations, 1) Butte Creek, and 2) Deer and Mill creeks. Although the spring-run Chinook salmon in Deer and Mill creeks represent a single genetically distinct subpopulation, they are considered in this Recovery Plan as two separate populations because Deer and Mill creeks provide two discrete spawning areas with independent population dynamics Lindley *et al*. (2004).

The FRFH was constructed in the mid-1960s by DWR to mitigate for the loss of Chinook salmon and steelhead spawning habitat by construction of Oroville Dam. The FRFH was opened in 1967 (DWR 2002) and is operated by CDFW. The FRFH is the only hatchery in the Central Valley producing spring-run Chinook salmon. The current production target for spring-run Chinook salmon at the FRFH is two million smolts.

Prior to 2004, FRFH hatchery staff differentiated spring-run from fall-run by opening the ladder to the hatchery on September 1. Those fish ascending the ladder from September 1 through September 15 were assumed to be spring-run Chinook salmon while those ascending the ladder after September 15 were assumed to be fall-run (Kastner 2003). This practice led to considerable hybridization between spring- and fall-run Chinook salmon (DWR 2004a). Since 2007, the fish ladder remains open for 9.5 months of the year (September 15 through June 30) and those fish ascending the ladder are marked with an external tag and returned to the river. This practice allows FRFH staff to identify those previously marked fish as phenotypic spring-run when they re-enter the ladder in September reducing the potential for hybridization between the spring and fall runs (DWR 2004a).

The FRFH also releases a significant portion of its spring-run production into San Pablo Bay (1,000,000 juvenile smolts). This practice increases the chances that these fish will stray into other Central Valley streams when they return as adults to spawn. This straying has the potential for genetic hybridization to occur between FRFH spring-run with local spring-run and fall-run populations, increasing the risk of genetic introgression and subsequent homogeneity among Central Valley Chinook salmon runs. In addition, this straying has the potential to transfer genetic material from hatchery fish to wild naturally-spawning fish and is generally viewed as an adverse hatchery impact. Of particular concern would be the straying of hatchery fish into Deer, Mill, or Butte creeks, affecting the genetic integrity of the only significantly distinct spring-run Chinook salmon in the Central Valley (DWR 2004a). **Figure 2-7** shows the total Central Valley spring-run Chinook salmon spawning run size estimates broken down by constituent component for the years 1970 through 2008. The figure indicates that since about 1982, the proportion of the spring-run in the Central Valley comprised of FRFH fish has substantially increased. The current and historical distribution of Central Valley spring-run Chinook salmon was presented in **Figure 2-4**.

Table 2-3. Temporal Occurrence of Adult and Juvenile Sacramento River Spring-run Chinook Salmon in the Sacramento River

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult																								
Sacramento River Basin[1,2]					▒	▒	▒	▒	▓	▓	▓	▓	▒	▒	▒	▒	▒	▒						
Sacramento River[3]					▒	▒	▒	▒	▒	▒	▒	▒	▒	▒										
Mill Creek[4]					░	░	▒	▓	▓	▓	▓	▒	▒	░	░									
Deer Creek[4]					░	░	▒	▓	▓	▓	▓	▒	▒											
Butte Creek[4]			▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒										
Juvenile																								
Sacramento River Tributaries[5]	▒	▒	▒	▒	▒	▒													▒	▒	▓	▓	▓	▓
Upper Butte Creek[6]	▓	▓	▓	▓	▒	▒	▒	▒	▒	▒	░	░							░	░	░	░	▓	▓
Mill, Deer, Butte Creeks[4]	▓	▓	▓	▓	▒	▒	▒	▒	▒	▒	░	░							░	░	░	░	░	░
Sacramento River at RBDD[3]	▓	▓	░	░	░	░	░	░													▓	▓	▓	▓
Sacramento River at KL[7]	▒	▒	▓	▓	▓	▓	▓	▓	▓	▓	▒	▒	░	░	░	░	░	░	░	░	░	░	▓	▓
Chipps Island (Trawl)[8*]	▒	▒	▓	▓	▓	▓	▓	▓	▓	▓	▒	▒	░	░	░	░	░	░	░	░	░	░	▓	▓

Sources: [1]Yoshiyama et al. 1998; [2]Moyle 2002; [3]Myers et al. 1998; [4]Lindley et al. 2006a; [5]CDFW 1998; [6]McReynolds et al. 2005; Ward et al. 2002, 2003; [7]Snider and Titus 2000, [8]USFWS 2001

Relative Abundance: ▓ = High ▒ = Medium ░ = Low

* Note: By the time yearly spring-run Chinook salmon reach Chipps Island they cannot be distinguished from fall-run yearlings.

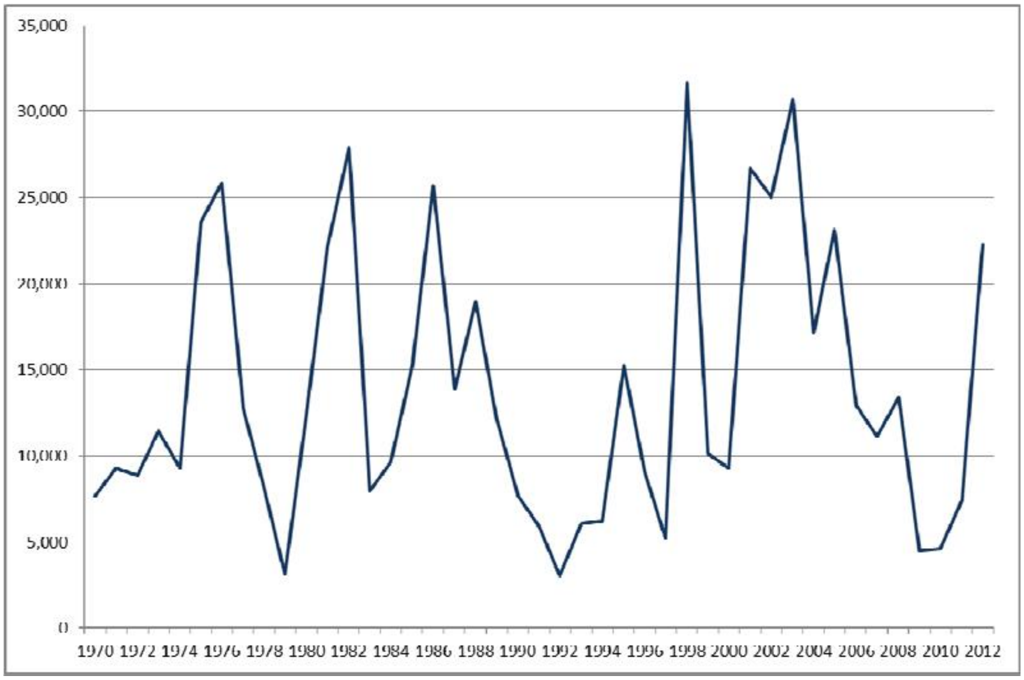


Figure 2-5. Central Valley Spring-run Chinook Salmon Run Size Estimates (1970–2012).

Source: (CDFW GRANDTAB http://www.fws.gov/stockton/*)*

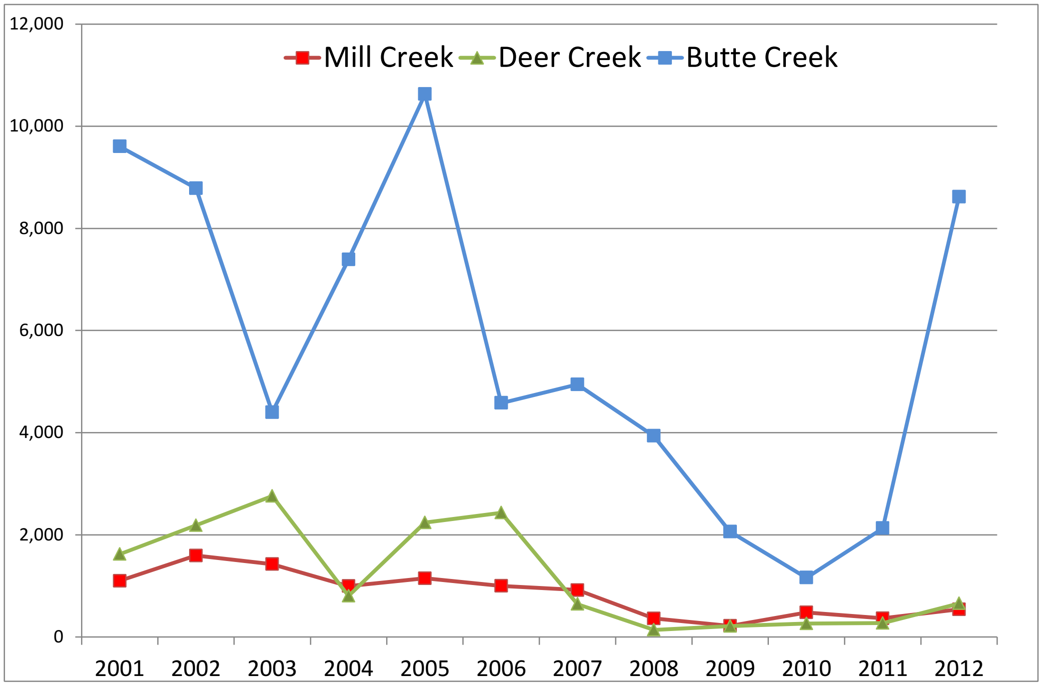


Figure 2-6. Mill, Deer, and Butte Creek Spawning Run Size Estimates for Central Valley Spring-run Chinook Salmon (2001–2012). All estimates were obtained by snorkel surveys. Source: (CDFW GRANDTAB and Annual Reports)

2.2.5 Critical Habitat

When designating critical habitat, NMFS focuses on “Primary Constituent Elements” (PCEs), which are the principal biological or physical constituent elements within the defined area that are essential to the conservation of the listed species (50 CFR 424.12(b)). PCEs considered essential for the conservation of the Central Valley spring-run Chinook salmon ESU are those sites and habitat components that support one or more life stages(50 CFR 226.211(c)), including:

- ☐ Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.
- ☐ Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.
- ☐ Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.
- ☐ Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

NMFS proposed[4] critical habitat for Central Valley spring-run Chinook salmon on December 10, 2004 (69 FR 71880), and published a final rule designating critical habitat for this species on September 2, 2005 (70 FR 52488). **Figure 2-8** depicts the designated critical habitat and distribution for Central Valley spring-run Chinook salmon.

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[4] NMFS proposed critical habitat for Central Valley spring-run Chinook salmon on February 5, 1999 (63 FR 11482) in compliance with Section 4(a)(3)(A) of the ESA, which requires that, to the maximum extent prudent and determinable, NMFS designates critical habitat concurrently with a determination that a species is endangered or threatened (NMFS 1999). On February 16, 2000 (65 FR 7764), NMFS published a final rule designating critical habitat for Central Valley spring-run Chinook salmon. Critical habitat was designated to include all river reaches accessible to listed Chinook salmon in the Sacramento River and its tributaries in California. Also included were river reaches and estuarine areas of the Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge.

In response to litigation brought by the National Association of Homebuilders (NAHB) (NAHB v. Evans, 2002 WL 1205743 No. 00–CV–2799 (D.D.C.)), NMFS sought judicial approval of a consent decree withdrawing critical habitat designations for 19 Pacific salmon and *O. mykiss* ESUs. The District Court in Washington DC approved the consent decree and vacated the critical habitat designations by Court order on April 30, 2002 (NAHB v. Evans, 2002 WL 1205743 (D.D.C. 2002)).

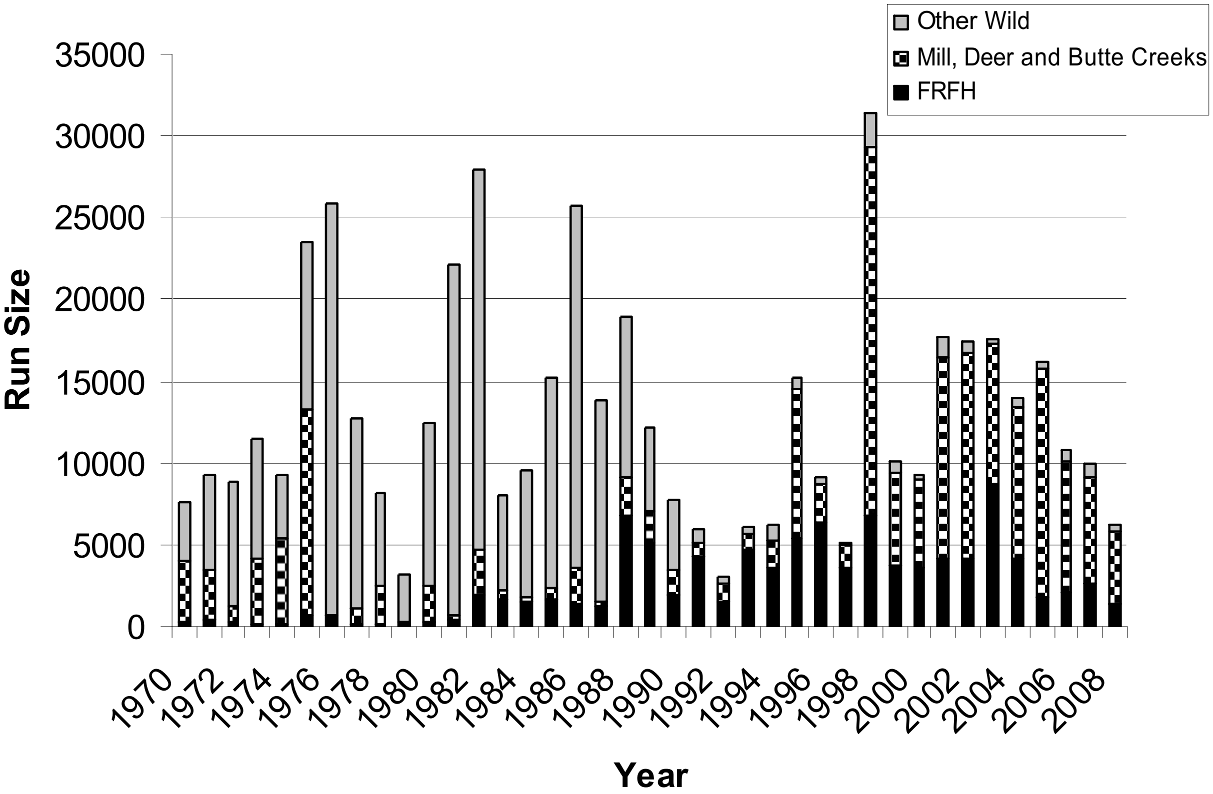
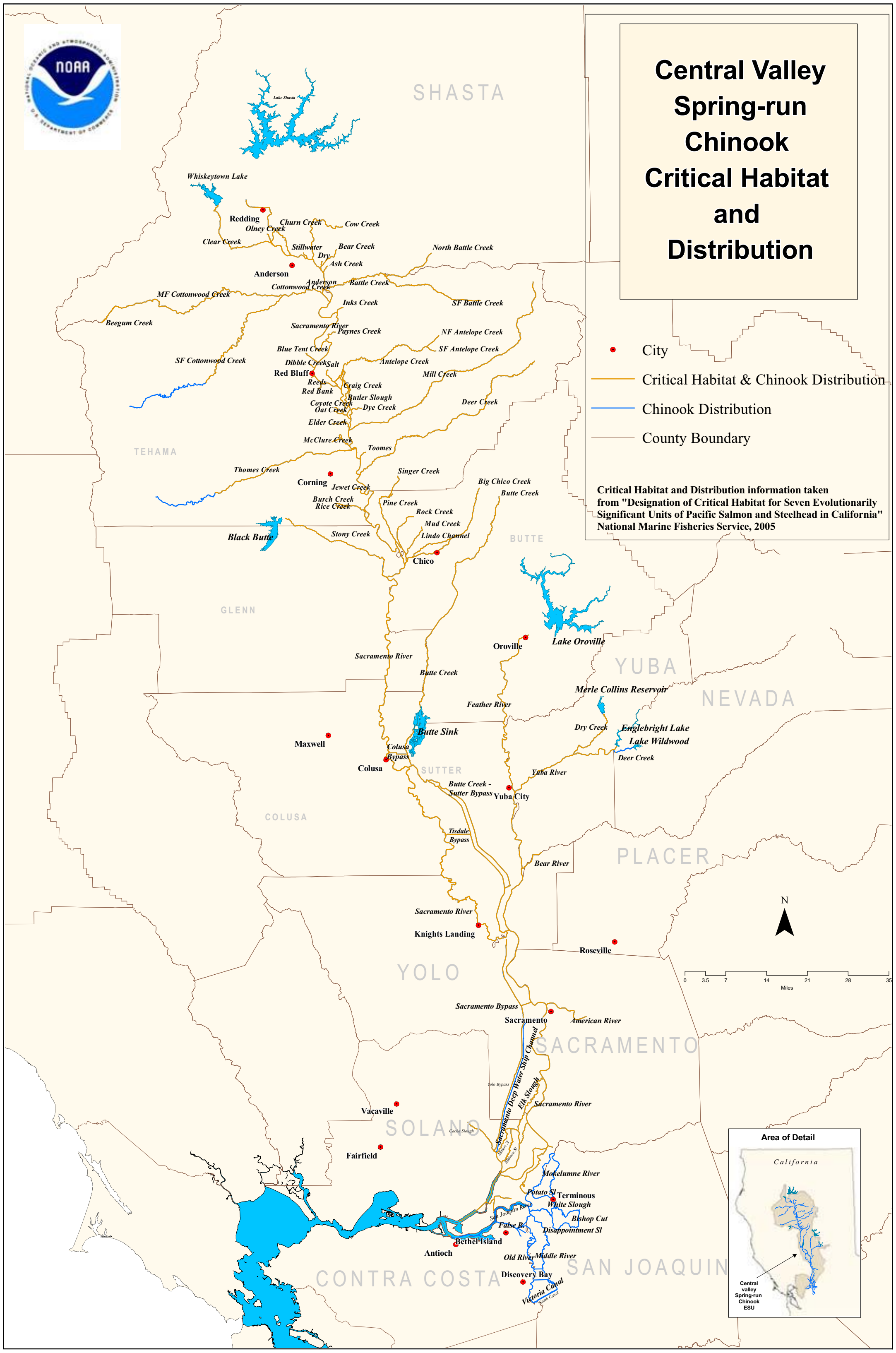


Figure 2-7. Central Valley Spring-run Chinook Salmon Spawning Run Size Composition (1970–2008)

Source: (CDFW GRANDTAB 2009)



Critical Habitat and Distribution information taken from "Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California" National Marine Fisheries Service, 2005

Figure 2-8. Central Valley Spring-run Chinook Salmon Designated Critical Habitat and Distribution

2.2.6 Reasons for Listing

The Central Valley spring-run Chinook salmon ESU is currently faced with three primary threats: (1) loss of most historic spawning habitat; (2) degradation of the remaining habitat; and (3) genetic introgression with the FRFH spring-run Chinook salmon strays. Spring-run Chinook salmon require cool freshwater in summer, most of which is upstream of impassable dams. The ESU is currently limited to independent populations in Mill, Deer, and Butte creeks, persistent and presumably dependent populations in the Feather and Yuba rivers and in Big Chico, Antelope, and Battle creeks, and a few ephemeral or dependent populations in the Northwestern California region (e.g., Beegum, Clear, and Thomes creeks). This ESU continues to be threatened by habitat loss, degradation and modification, small hydropower dams and water diversions that reduce or eliminate instream flows during migration, unscreened or inadequately screened water diversions, excessively high water temperatures, and predation by non-native species.

The potential effects of climate change are likely to adversely affect spring-run Chinook salmon and their recovery. These effects are more thoroughly discussed in Chapter 6.

Listing Factors for Spring-run Chinook Salmon

Section 4 of the ESA requires the Secretary of the Interior or Commerce, depending upon the species involved, to determine if any species is an endangered or threatened species for any of the following listing factors: (1) present or threatened destruction, modification or curtailment of its habitat or range; (2) overutilization for commercial, recreational. scientific or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence. Each of these listing factors with respect to spring-run Chinook salmon are summarized below.

The Present or Threatened Destruction, Modification, or Curtailment of Spring-run Chinook Salmon's Habitat or Range.

Habitat Loss

Loss of historic spawning habitat was a major reason for listing spring-run Chinook salmon under the ESA and it remains an important threat, as most of that habitat continues to be blocked by the direct or indirect effects of dams. Perhaps 15 of the 19 historical populations of Central Valley spring-run Chinook salmon are extinct, with their entire historical spawning habitats behind various impassable dams (Lindley *et al*. 2007). The construction of dams in the Central Valley has eliminated virtually all historic spawning habitat of spring-run Chinook salmon in the basin. Native spring-run Chinook salmon have been extirpated from all tributaries in the San Joaquin River Basin, which represents a large portion of the historic range and abundance of the ESU.

Like most spring-run Chinook salmon, Central Valley spring-run Chinook salmon require cool freshwater while they mature over the summer. In the Central Valley, summer water temperatures are reportedly suitable for Chinook salmon only above 150 to 500-m elevations, and most of that high elevation habitat is now upstream of impassable dams (NMFS 2005). Current spawning is restricted to the mainstem and a few river tributaries in the Sacramento River

(NMFS 1998). Naturally-spawning populations of Central Valley spring-run Chinook salmon currently are restricted to accessible reaches of the upper Sacramento River, Antelope Creek, Battle Creek, Beegum Creek, Big Chico Creek, Butte Creek, Clear Creek, Deer Creek, Feather River, Mill Creek, and Yuba River (CDFW 1998).

The construction of Shasta and Keswick dams on the Sacramento River and Oroville Dam on the Feather River and subsequent blocking of upstream migration has eliminated the spatial separation between spawning fall-run and spring-run Chinook salmon. Reportedly, spring-run Chinook salmon migrated to the upper Feather River and its tributaries from mid-March through the end of July (CDFW 1998). Fall-run Chinook salmon reportedly migrated later and spawned in lower reaches of the Feather River than spring-run Chinook salmon (Yoshiyama *et al.* 2001). The same pattern likely also existed on the Sacramento River. Restricted access to historic spawning grounds currently causes spring-run Chinook salmon to spawn in the same lowland reaches that fall-run Chinook salmon use as spawning habitat. The overlap in spawning site locations, combined with an overlap in spawning timing (Moyle 2002) with temporally adjacent runs, is responsible for interbreeding between spring-run and fall-run Chinook salmon in the lower Feather River (Hedgecock *et al.* 2001) and in the Sacramento River below Keswick Dam.

In the upper Sacramento River, lower Feather River, and lower Yuba River, spring-run Chinook salmon spawning may occur a few weeks earlier than fall-run spawning, but currently there is no clear distinction between the two because of the disruption of spatial segregation by Shasta and Keswick dams on the Sacramento River, Oroville Dam on the Feather River, and Englebright Dam on the Yuba River. Thus, spring-run and fall-run Chinook salmon spawning overlap temporally and spatially. This presents difficulties from a management perspective in determining the proportional contribution of total spawning escapement by the spring- and fall-runs. Because of unnaturally high densities of spawning, particularly in the in the Low Flow Channel of the Feather River, spawning habitat is likely a limiting factor. Intuitively, it could be inferred that the slightly earlier spawning Chinook salmon displaying spring-run behavior would have better access to the limited spawning habitat, although early spawning likely leads to a higher rate of redd superimposition. Redd superimposition occurs when spawning Chinook salmon dig redds on top of existing redds dug by other Chinook salmon. The rate of superimposition is a function of spawning densities and typically occurs in systems where spawning habitat is limited (Fukushima *et al.* 1998). Redd superimposition may disproportionately affect early spawners and, therefore, potentially affect Chinook salmon exhibiting spring-run life history characteristics.

Habitat Degradation

Another major reason why spring-run Chinook salmon are in need of ESA protection is because the remaining spawning and rearing habitat for this species is severely degraded (63 FR 11482, March 9, 1998; Myers *et al.* 1998; Good *et al.* 2005; NMFS 2011b). Threats to spring-run Chinook salmon habitat include, but are not limited to: (1) operation of antiquated fish screens, fish ladders, and diversion dams on streams throughout the Sacramento River Basin including on Deer, Mill, Butte, and Antelope creeks; (2) levee construction and maintenance projects that have greatly simplified riverine habitat and have disconnected rivers from the floodplain; and (3) water delivery and hydroelectric operation on the main-stem Sacramento River (Central Valley Project), and the Feather River (State Water Project).

General degradation of rearing and migrating habitat includes elevated water temperatures, agricultural and municipal diversions and returns, restricted and regulated flows, entrainment of migrating fish into unscreened or poorly screened diversions, predation by nonnative species, and the poor quality and quantity of remaining habitat (NMFS 1998). Hydropower dams and water diversions in some years have greatly reduced or eliminated in-stream flows during spring-run migration periods (NMFS 1998b).

Overutilization of Spring-run Chinook Salmon for Commercial, Recreational, Scientific, or Educational Purposes

Overutilization of spring-run Chinook salmon for commercial, recreational, scientific, or educational purposes was not identified as an important risk to spring-run Chinook salmon when the species was listed in 1999 (63 FR 11482; March 9, 1998). The spring-run Chinook salmon status review that informed the 1999 listing determination stated that, "*Harvest rates* [of spring-run Chinook salmon] *appear to be moderate*. (Myers *et al*. 1998)." No spring-run Chinook salmon ocean harvest rate data were available to support that statement. Some limited information obtained since spring-run Chinook salmon were listed suggests that harvest in the ocean fisheries may be more of a risk to the species than originally thought. An analysis done by Grover *et al*. (2004) indicated that Butte Creek spring-run Chinook salmon are vulnerable to the commercial and recreational ocean salmon fisheries with an estimated 36 percent of brood year 1998 and 42 percent of brood year 1999 harvested in the ocean, respectively. Those harvest rates are about twice that of winter-run Chinook salmon (NMFS 2010c). Grover *et al*. (2004) cautioned the interpretation of their own results because of the low number of coded wire tag recoveries and the analysis covered just two cohorts. Further analysis of spring-run Chinook salmon harvest rates is needed to better understand the ocean fisheries' impacts on this ESU.

Disease or Predation

Disease

Disease was not an important factor in the listing of spring-run Chinook salmon (63 FR 11482, March 9, 1998; Myers *et al*. 1998). There is no evidence that spring-run Chinook salmon have experienced unusual levels of disease in the wild. There have been numerous outbreaks of infectious hematopoietic necrosis virus (IHNV) in Chinook salmon at CNFH and the FRFH. Although the virus had been detected in stream salmonids, there have been no reported epizootics of IHNV in Central Valley stream populations (i.e., the virus was detected but the fish themselves were asymptomatic of the disease) (DWR 2009). It appears that IHNV is not readily transmitted from hatchery fish to salmon and other fish in streams, estuary or the ocean (DWR 2009).

Predation

Predation was not identified as an important factor in the listing of spring-run Chinook salmon (63 FR 11482, March 9, 1998; Myers *et al*. 1998), but more recently it has gained attention as a potentially significant source of mortality (Moyle 2002; Vogel

2011). See section 2.1.6 above for information on predators of juvenile Chinook salmon in the Central Valley and their potential impact.

The Inadequacy of Existing Regulatory Mechanisms

Laws relevant to the protection and restoration of spring-run Chinook salmon are the ESA, the Magnuson-Stevens Fishery Conservation and Management Act, the CVPIA, the Federal Power Act, the Fish and Wildlife Coordination Act, the Clean Water Act, the National Environmental Policy Act, and numerous State laws administered by CDFW, DWR, or the SWRCB. These laws and associated regulations provide adequate mechanisms for recovering spring-run Chinook salmon; however some of the goals of these existing mechanisms have not yet been achieved. The effectiveness of applying the regulatory mechanisms is to some extent controlled by societal values. The people of California will need to place a higher value on improving natural ecosystems in order for existing regulatory mechanisms to be most effective at recovering anadromous salmonids in the Central Valley.

Other Natural or Manmade Factors Affecting the Continued Existence of Spring-run Chinook Salmon

Reduced Genetic Integrity

Threats to the genetic integrity of spring-run Chinook salmon was identified as a serious concern to the species when it was listed in 1999 (63 FR 11482, March 9, 1998; Myers *et al*. 1998). Three main factors compromised the genetic integrity of spring-run Chinook salmon: (1) the lack of reproductive isolation following dam construction throughout the Central Valley resulting in introgression with fall-run Chinook salmon in the wild; (2) within basin and inter-basin mixing between spring- and fall- broodstock for artificial propagation, resulting in introgression in hatcheries; and (3) releasing hatchery-produced juvenile Chinook salmon in the San Francisco estuary, which contributes to the straying of returning adults throughout the Central Valley.

In the 1940s, trapping of adult Chinook salmon that originated from areas above Keswick and Shasta dams may have resulted in stock mixing, and further mixing with fall-run Chinook salmon apparently occurred with fish transferred to the CNFH. Deer Creek, one of the locations generally believed most likely to retain essentially native spring-run Chinook salmon, was a target of adult outplants from the 1940s trapping operation, but the success of those transplants is uncertain (Myers *et al*. 1998).

Much of the Central Valley Chinook salmon production is of hatchery origin, and over the years hatchery fish have interbred with wild populations of both fall-run and spring-run Chinook salmon. This problem has been exacerbated by the continued practice of trucking juvenile Chinook salmon to the Delta for release, contributing to the straying of returning adults throughout the Central Valley.

The FRFH spring-run Chinook salmon program releases half its production near the hatchery and the other half is released far downstream of the hatchery (CDFW 2001a). Given the large number of juveniles released off station, the potential contribution of straying adults to rivers throughout the Central Valley is considerable (Myers *et al*. 1998). Cramer (1996) reported that up to 20 percent of the Feather River spring-run Chinook salmon are recovered in the

American River sport fishery. From 2004 through 2010 on the Yuba River, hatchery origin Chinook salmon accounted for an average of 21.4% of the total annual run of spring-run Chinook salmon passing upstream of Daguerre Point Dam (USACE 2012). Analysis of coded wire tags suggests that most of those hatchery fish originated from the FRFH (USACE 2012).

Catastrophic Environmental Disturbance

Although not identified as a reason for listing spring-run Chinook salmon under the ESA, the potential for a catastrophic environmental disturbance has more recently been recognized as a key threat to the species. Lindley *et al.* (2007) report that the current distribution of viable populations makes the Central Valley spring-run Chinook salmon ESU vulnerable to catastrophic disturbance. All three extant independent populations are in basins whose headwaters lie within the debris and pyroclastic flow radii of Lassen Peak, an active volcano that USGS views as highly dangerous. Additionally, a fire with a maximum diameter of 30 km, big enough to burn the headwaters of Mill, Deer, and Butte creeks simultaneously, has roughly a 10 percent chance of occurring somewhere in the Central Valley each year. Impacts on salmon and their habitat from fires include potential death during a fire that goes through a drainage, reduced water quality from fire suppression activities and associated chemicals, increased water temperatures from lost canopy, increased sedimentation, and reduced habitat complexity and large woody debris. A catastrophic environmental disturbance affecting Mill, Deer, and Butte creeks would greatly reduce the abundance and distribution of the spring-run Chinook salmon ESU.

2.2.7 Threats Assessment

A detailed threats assessment was conducted for the Central Valley spring-run Chinook salmon ESU, and followed the same general procedure previously described for winter-run Chinook salmon. The threats/stressors affecting each spring-run Chinook salmon diversity group and population are described in Appendix B.

The completed stressor matrix sorted by normalized weight is a prioritized list of the life stage-specific stressors affecting the ESU. For spring-run Chinook salmon, threats were prioritized within each diversity group, as well as within each population. Specific information explaining the individual steps taken to generate these prioritized lists are provided in Appendix B.

Some major stressors to the entire Central Valley spring-run Chinook salmon ESU include passage impediments/barriers, ocean harvest, warm water temperatures for holding and rearing, limited quantity and quality of rearing habitat, predation, and entrainment. The complete prioritized list of life stage-specific stressors to this ESU is presented in Appendix B.

Some of the most important specific stressors to each diversity groups within the ESU are described below.

Northern Sierra Nevada Diversity Group

- ☐ Agricultural diversions, diversion dams, and/or weirs on Deer, Mill, Antelope, and Butte creeks impeding or blocking access to upstream spawning habitat;
- ☐ Warm water temperatures in Antelope, Butte, and Big Chico creeks during the adult immigration

and holding life stage, especially in dry or extreme years;

- Englebright Dam blocking access to habitat historically used by Yuba River spring-run Chinook salmon;
- Oroville Dam blocking access to habitat historically used by Feather River spring-run Chinook salmon;
- Entrainment in Antelope Creek resulting from terminal diversions and loss of channel connectivity;
- Loss of rearing habitat in the lower and middle sections of the Sacramento River and in the Delta;
- Ocean harvest on all populations; and
- Predation on juveniles from all populations rearing and migrating through the Sacramento River and Delta.

Basalt and Porous Lava Diversity Group

- Keswick and Shasta dams blocking access to habitat historically used by spring-run Chinook salmon in the upper Sacramento River watershed;
- Passage impediments and flow fluctuations resulting from hydropower operations on the North and South Forks of Battle Creek;
- Loss of rearing habitat in the Sacramento River and Delta;
- Ocean harvest on all populations; and
- Predation on juveniles from all populations rearing and migrating through the Sacramento River and Delta.

Northwestern California Diversity Group

- Warm water temperatures in all three watersheds during the adult immigration and holding life stage;
- Limited spawning habitat availability in all three watersheds;
- Loss of rearing habitat in the lower and middle sections of the Sacramento River and in the Delta;
- Whiskeytown Dam blocking access to habitat potentially historically used by Clear Creek spring-run Chinook salmon;
- Ocean harvest on all populations; and
- Predation on juveniles from all populations rearing and migrating through the Sacramento River and Delta.

2.2.8 Conservation Measures

ERP and CVPIA actions in the Sacramento River tributaries have focused on riparian and shaded riverine aquatic habitat restoration, improved access to available upstream habitat, improved instream flows, and reduced loss of juveniles at diversions, particularly for spring-run Chinook salmon and steelhead. For a description of ERP, CVPIA and other actions, refer to the previous discussion of Conservation Measures for winter-run Chinook salmon.

The Delta Pumping Plant Fish Protection Agreement (Delta Agreement) signed in 1986 was intended to mitigate for SWP and pumping plant impacts. From 1986 through 2007, approximately $60 million from the Delta Agreement has been spent on over 40 fish mitigation projects. These funds resulted in the screening of water diversions, enhanced law enforcement efforts to reduce illegal fish harvest, installation of seasonal barriers to guide fish away from undesirable spawning habitat or migration corridors, salmon habitat restoration, and removal of four dams to improve fish passage on Butte Creek for Chinook and steelhead. Approximately one-third of the approved funding for salmon projects specifically targeted spring-run Chinook salmon and steelhead in the upper Sacramento River tributaries. Projects implemented under the agreement that have most directly benefited spring-run Chinook salmon include water exchange projects to improve passage flows on Mill and Deer creeks, and fish screens and fish ladder improvements on Butte Creek.

Harvest protective measures benefiting spring-run Chinook salmon include seasonal constraints on sport and commercial fisheries south of Point Arena. In addition, the State has listed spring-run Chinook under the CESA, and has thus established specific in-river fishing regulations and no-retention prohibitions designed to protect this ESU (e.g., fishing method restrictions, gear restrictions, bait limitations, seasonal closures, and zero bag limits), in tributaries such as Deer, Big Chico, Mill, and Butte creeks.

2.3 Steelhead

2.3.1 ESA Listing Status

NMFS proposed to list Central Valley steelhead (anadromous *O. mykiss*), which is currently listed as threatened, as endangered on August 9, 1996 (61 FR 41541). NMFS concluded that the California Central Valley steelhead ESU was in danger of extinction because of habitat degradation and destruction, blockage of freshwater habitats, water allocation problems, the pervasive opportunity for genetic introgression resulting from widespread production of hatchery steelhead and the potential ecological interaction between introduced stocks and native stocks. Moreover, NMFS proposed to list steelhead as endangered because steelhead had been extirpated from most of their historical range.

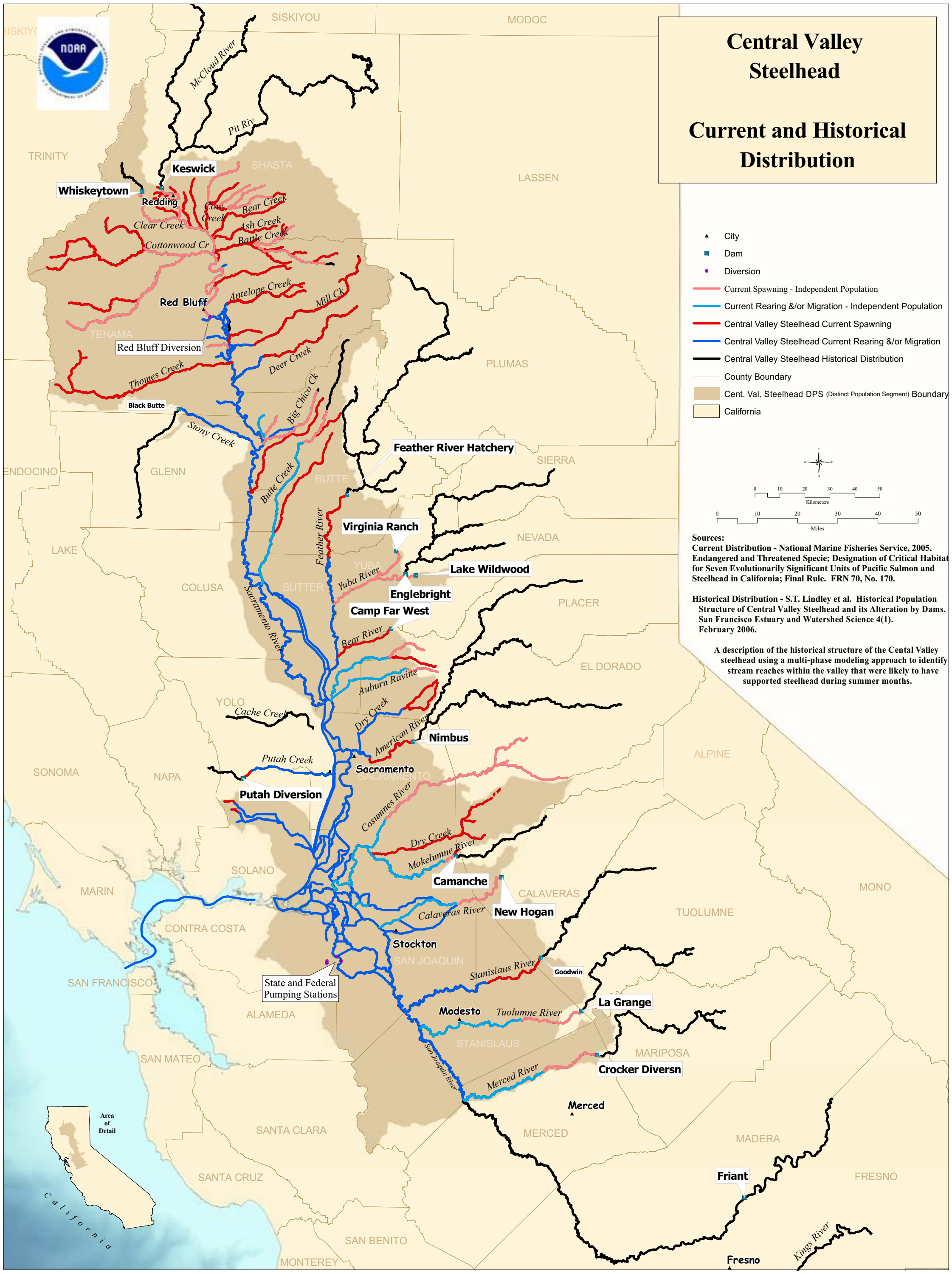
On March 19, 1998, NMFS listed the Central Valley steelhead as a threatened species (63 FR 13347). NMFS concluded that the risks to Central Valley steelhead had diminished since the completion of the 1996 status review based on a review of existing and recently implemented State conservation efforts and Federal management programs (e.g., CVPIA AFRP, CALFED) that address key factors for the decline of this species. In addition, NMFS noted that additional actions benefiting Central Valley steelhead included efforts to enhance fisheries monitoring and conservation actions to address artificial propagation.

On September 8, 2000, pursuant to a July 10, 2000, rule issued by NMFS under Section 4(d) of the ESA (16 USC § 1533(d)), the take restrictions that apply statutorily to endangered species began to apply with specific limitations to Central Valley steelhead (65 FR 42422). On January 5, 2006, NMFS reaffirmed the threatened status of the Central Valley steelhead and applied the DPS policy to the species because the resident and anadromous life forms of steelhead remain “markedly separated” as a consequence of physical, ecological and behavioral factors, and may therefore warrant delineation as a separate DPS (71 FR 834). NMFS (1998) based its conclusion on conservation and protective efforts that, "*mitigate the immediacy of extinction risk facing the Central Valley steelhead DPS*." **Figure 2-9** depicts the California Central Valley steelhead DPS.

2.3.2 Species Description and Taxonomy

Steelhead and rainbow trout are the same species. In general, steelhead refers to the anadromous form of the species. Normally, adult steelhead reach a larger size than resident rainbow trout. Sacramento River Basin steelhead immigrants range in size from 12 to 18 inches (30.5 to 45.7 cm) FL for adults returning after 1 year in the ocean, to 18 to 23 inches (45.7 to 58.4 cm) FL for adults returning after 2 years in the ocean (S.P. Cramer & Associates 1995).

Steelhead can be identified by the numerous black spots on the caudal fin, adipose fin, dorsal fin and back (Moyle 2002). When in freshwater, steelhead often display the pinkish to red lateral band and cheeks typical of resident rainbow trout. The back is normally an iridescent blue to brown, the sides and belly are silver, white or yellowish (Moyle 2002). The resident forms are usually darker than the sea-run. Juvenile coloration is similar to adults except that juveniles often have 8 to 13 widely spaced parr marks centered on the lateral line, 5 to 10 dark marks on the back between the head and dorsal fin, white to orange tips on the dorsal and anal fins, and few, if any, dark spots on the tail (Moyle 2002).


Central Valley Steelhead

Current and Historical Distribution

Sources:
Current Distribution - National Marine Fisheries Service, 2005. Endangered and Threatened Specie; Designation of Critical Habitat for Seven Evolutionarily Significant Units of Pacific Salmon and Steelhead in California; Final Rule. FRN 70, No. 170.

Historical Distribution - S.T. Lindley et al. Historical Population Structure of Central Valley Steelhead and its Alteration by Dams. San Francisco Estuary and Watershed Science 4(1). February 2006.

A description of the historical structure of the Cental Valley steelhead using a multi-phase modeling approach to identify stream reaches within the valley that were likely to have supported steelhead during summer months.

Figure 2-9. California Central Valley Steelhead Distinct Population Segment, and Current and Historical Distribution. See Lindley *et al.* 2006 (Table 1) in Appendix C for a list of the 81 historic independent steelhead populations in the Central Valley**.** Note: this figure does not include populations in the Suisun Bay Tributaries diversity group, the Central Western diversity group, or populations in the southern Sierra Nevada diversity group that are south of the upper San Joaquin River.

2.3.3 Life History/Habitat Requirements

Life History

Oncorhynchus mykiss may exhibit anadromy or freshwater residency. Resident forms are usually referred to as rainbow trout, while anadromous life forms are termed ‘‘steelhead.’’ Zimmerman *et al.* (2008) demonstrated that resident rainbow trout can produce anadromous smolts and anadromous steelhead can produce resident rainbow trout in the Central Valley. That study indicated that the proportion of resident rainbow trout to anadromous steelhead in the Central Valley is largely in favor of the resident form with 740 of 964 *O. mykiss* examined being the progeny of resident rainbow trout (Zimmerman *et al.* 2008).

Steelhead typically migrate to marine waters after spending two years in fresh water. They reside in marine waters for typically two or three years prior to returning to their natal stream to spawn as four- or five-year-olds. Unlike Pacific salmon, steelhead are capable of spawning more than once before they die. However, it is rare for steelhead to spawn more than twice before dying, and most that do so are females (Moyle 2002).

Currently, Central Valley steelhead are considered “ocean-maturing” (also known as winter) steelhead, although summer steelhead may have been present prior to construction of large dams (Moyle 2002). Ocean maturing steelhead enter fresh water with well-developed gonads and spawn shortly after river entry. Central Valley steelhead enter fresh water from August through April. They hold until flows are high enough in tributaries to enter for spawning (Moyle 2002). Steelhead adults typically spawn from December through April, with peaks from January through March in small streams and tributaries where cool, well oxygenated water is available year-round (Hallock *et al.* 1961; McEwan 2001). Depending on water temperature, steelhead eggs may incubate in redds for over one month before hatching as alevins. Following yolk sac absorption, alevins emerge from the gravel as young juveniles or fry and begin actively feeding (Moyle 2002).

In the Sacramento River, juvenile steelhead generally migrate to the ocean in spring and early summer at 1 to 3 years of age and 10 to 25 cm FL, with peak migration through the Delta in March and April (Reynolds *et al.* 1993). Hallock *et al.* (1961) found that juvenile steelhead in the Sacramento River Basin migrate downstream during most months of the year, but the peak emigration period occurred in the spring, with a much smaller peak in the fall.

Table 2-4 depicts the temporal occurrence of steelhead life stages in the Sacramento River. Steelhead may remain in the ocean from one to four years, growing rapidly as they feed in the highly productive currents along the continental shelf (Barnhart 1986). Oceanic and climate conditions such as sea surface temperatures, air temperatures, strength of upwelling, El Niño events, salinity, ocean currents, wind speed, and primary and secondary productivity affect all facets of the physical, biological and chemical processes in the marine environment. Some of the conditions associated with El Niño events include warmer water temperatures, weak upwelling, low primary productivity (which leads to decreased zooplankton biomass), decreased southward transport of subarctic water, and increased sea levels (Pearcy 1997). For juvenile steelhead, warmer water and weakened upwellings are possibly the most important of the ocean conditions associated with El Niño. Because of the weakened upwelling during an El Niño year, juvenile California steelhead would need to migrate more actively offshore through possibly stressful warm waters with numerous inshore predators.

Strong upwelling is probably beneficial because of the greater transport of smolts offshore, beyond major concentrations of inshore predators (Pearcy 1997).

Habitat Requirements

A description of freshwater habitat requirements for steelhead is presented in the following sections. Habitat requirements are organized by the species life stage.

Adult Immigration and Holding

Adult steelhead immigration into Central Valley streams typically begins in August and continues into March (McEwan 2001; NMFS 2004). Steelhead immigration generally peaks during January and February (Moyle 2002). Optimal immigration and holding temperatures have been reported to range from 46°F to 52°F (CDFW 1991b).

Central Valley steelhead are known to use the Sacramento River as a migration corridor to spawning areas in upstream tributaries. Historically, steelhead likely did not utilize the mainstem Sacramento River downstream from the Shasta Dam site except as a migration corridor to and from headwater streams. Likewise, the Feather River below the current site of Oroville Dam was likely used only as a migration corridor to upstream reaches.

Adult Spawning

Central Valley steelhead spawn downstream of dams on every major tributary within the Sacramento and San Joaquin River systems. The female steelhead selects a site with good intergravel flow, digs a redd with her tail, usually in the coarse gravel of the tail of a pool or in a riffle, and deposits eggs while an attendant male fertilizes them. Water velocities over redds are typically 20 to 155 cm/sec, and depths are 10 to 150 cm (Moyle 2002). The preferred water temperature range for steelhead spawning is reported to be 30°F to 52°F (CDFW 2000).

Embryo Incubation

Following deposition of fertilized eggs in the redd, they are covered with loose gravel. Central Valley steelhead eggs can reportedly survive at water temperature ranges of 35.6°F to 59°F (Myrick and Cech 2001). However, steelhead eggs reportedly have the highest survival rates at water temperature ranges of 44.6°F to 50.0°F (Myrick and Cech 2001). The eggs hatch in three to four weeks at 50°F to 59°F, and fry emerge from the gravel four to six weeks later (Shapovalov and Taft 1954).

Juvenile Rearing and Outmigration

Regardless of life history strategy, for the first year or two of life rainbow trout and steelhead are found in cool, clear, fast-flowing permanent streams and rivers where riffles predominate over pools, there is ample cover from riparian vegetation or undercut banks, and invertebrate life is diverse and abundant (Moyle 2002). The smallest fish are most often found in riffles, intermediate size fish in runs, and larger fish in pools. Steelhead can be found where daytime water temperatures range from nearly 32°F to 81°F in the summer, although mortality may result at extremely low (i.e.,

<39°F) or extremely high (i.e., > ~73°F) water temperatures if the fish have not been gradually acclimated (Moyle 2002). Juvenile steelhead in northern California rivers reportedly exhibited increased physiological stress, increased agonistic activity, and a decrease in forage activity after ambient stream temperatures exceeded 71.6°F (Nielsen *et al*. 1994).

When water temperatures become stressful in streams, juvenile steelhead are faced with the increased energetic costs of living at high water temperatures. Hence, juvenile steelhead will move into fast flowing riffles to feed because of the increased abundance of food, even though there are costs associated with maintaining position in fast water. At higher water temperatures, steelhead are more vulnerable to stress which can be fatal (Moyle 2002). Predators also have a strong effect on microhabitats selected by steelhead. Small steelhead select places to live based largely on proximity to cover in order to hide from predators.

Optimal water temperatures for growth of steelhead have been reported to be 59°F to 64.4°F (Moyle 2002). Many factors affect choice of water temperatures by steelhead, including the availability of food. As steelhead grow, they establish individual feeding territories. Some juvenile steelhead utilize tidal marsh areas, non-tidal freshwater marshes, and other shallow water areas in the Delta as rearing areas for short periods prior to their final emigration to the ocean.

2.3.4 Abundance Trends and Distribution

Prior to dam construction, water development and watershed perturbations, Central Valley steelhead were distributed throughout the Sacramento and San Joaquin rivers (Busby *et al.* 1996; NMFS 1996b, McEwan 2001). Steelhead were found from the upper Sacramento and Pit rivers (now inaccessible due to Shasta and Keswick dams) south to the Kings and possibly the Kern River systems, and in both east- and west-side Sacramento River tributaries (Yoshiyama *et al.* 1996). Lindley *et al.* (Lindley *et al.* 2006) estimated that historically there were at least 81 independent Central Valley steelhead populations distributed primarily throughout the eastern tributaries of the Sacramento and San Joaquin rivers (**see Appendix C**). Presently, impassable dams block access to 80 percent of historically available habitat, and block access to all historical spawning habitat for about 38 percent of historical populations (Lindley *et al.* 2006).

The current and historical distribution of Central Valley steelhead was presented in **Figure 2-9**. Existing wild steelhead populations in the Sacramento River basin occur in the upper Sacramento River and its tributaries, including Cottonwood, Antelope, Deer, and Mill creeks and the Yuba River. Other Sacramento River basin populations may exist in Big Chico and Butte creeks, and a few wild steelhead are produced in the American and Feather rivers (McEwan 2001). Snorkel surveys conducted from 1999 to 2008 indicate that steelhead are present in Clear Creek (Giovannetti and Brown 2009; Good *et al.* 2005). Monitoring data from 2005 to 2009 shows that steelhead are also present in Battle Creek (Newton and Stafford 2011).

A hatchery supported population of steelhead also occurs in the Mokelumne River, which flows directly into the Delta in between where the Sacramento and San Joaquin rivers enter the Delta.

Central Valley steelhead were thought to be extirpated from the San Joaquin River system, until recent monitoring detected small populations of *O.mykiss* in the Stanislaus, Mokelumne, and Calaveras rivers, and other streams previously thought to be devoid of steelhead (McEwan 2001). It is uncertain whether the *O.mykiss* in those rivers are predominantly resident or anadromous *O.mykiss*; presumably, both the anadromous and resident life history form of *O.mykiss* are present. On the Stanislaus River, small numbers of steelhead smolts have been captured in rotary screw traps at Caswell State Park and Oakdale each year since 1995 (S.P. Cramer and Associates Inc. 2000, 2001). Steelhead also currently occur in the Stanislaus, Calaveras, Merced, and Tuolumne rivers.

It is possible that naturally-spawning populations exist in many other streams but are undetected due to lack of monitoring programs (IEP Steelhead Project Work Team 1999). Incidental catches and observations of steelhead juveniles also have occurred on the Tuolumne and Merced Rivers during fall-run Chinook salmon monitoring activities, indicating that *O.mykiss* are widespread, throughout accessible streams and rivers in the Central Valley (Good *et al.* 2005).

Table 2-4. The Temporal Occurrence of Adult and Juvenile Steelhead in the Sacramento River

Location	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Adult																								
Sacramento River[1,3]	░	░	░	░	░	░						░	░	░	░	▒	▒	▓	▓	▒	░	░	░	░
Sacramento River at Red Bluff[2,3]	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	░	▒	▒	▓	▒	░	░	░	░
Mill, Deer Creeks[4]			▓	▒	▒	░	░	░	░	░	░	░								▓	▓	▒	▒	▒
Sacramento River at Fremont Weir[6]	░	░	░	░											▒	▒	▓	▓	▒	▒	░	░	░	░
Sacramento River at Fremont Weir[6]	░	░	░	░											▒	▒	▓	▓	▒	▒	░	░	░	░
San Joaquin River[7]	▒	▒	▒	▒	▒	▒							░	░	░	░	▒	▒	▒	▒	▒	▒	▓	▓
Juvenile																								
Sacramento River[1,2]	░	░	░	░	▒	▒	▒	▒	▒	▒	▒	▒	░	░	░	░	░	░	▒	▒	▒	▒	░	░
Sacramento River at Knights Landing[2,8]	░	░	░	░	▓	▓	░	░	░															░
Sacramento River at KL[9]	▒	▒	▒	▒	▓	▓	▓	▓	▒	▒											░	░	░	░
Chipps Island (Wild)[10]	░	░	░	░	▓	▓	▓	▓	▒	▒	▒	▒	░	░					░	░	░	░	░	░
Mossdale[8]							▓	▓	▓	▓														
Woodbridge Dam[11]	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒										
Stanislaus River at Caswell[12]	░	░	▒	▒	▓	▓	▒	▒	▒	▒	░	░												
Sacramento River at Hood[13]	░	░	▓	▓	▓	▓	▓	▓	▓	▓											░	░	░	░

Sources: [1]Hallock et al. 1961; [2]McEwan 2001; [3]USFWS unpublished data; [4]CDFW 1995; [5](Hallock et al. 1957); [6]Bailey 1954; [7]CDFW Steelhead Report Card Data; [8]CDFW unpublished data; [9]Snider and Titus 2000; [10]Nobriga and Cadrett 2003; [11]Jones & Stokes Associates, Inc., 2002; [12]S.P. Cramer and Associates, Inc. 2000 and 2001; [13]Schaffter 1980

Relative Abundance:	▓	= High	▒	= Medium	░	= Low

Note: NMFS recognizes that CDFW Steelhead Report Card Data provides a small sample size and involves some known sampling bias, but these data represent the best information available for the temporal distribution of adult steelhead in the San Joaquin River.

Historic Central Valley steelhead run sizes are difficult to estimate because of the lack of data, but may have approached one to two million adults annually (McEwan 2001). By the early 1960s the steelhead run size had declined to about 40,000 (CDFW 1996). Over the last 30 years the steelhead populations in the upper Sacramento River have declined substantially. In 1996, NMFS estimated the Central Valley total run size based on dam counts, hatchery returns, and past spawning surveys was probably fewer than 10,000 fish. Both natural and hatchery runs have declined since the 1960s. Counts at RBDD averaged 1,400 fish from 1991 to 1993, compared to counts in excess of 10,000 fish in the late 1960. Because of adverse impacts on winter-run Chinook salmon, the operation of RBDD was changed so that the dam gates were raised earlier in the season, and this eliminated the ability to generate steelhead run-size estimates (McEwan 2001).

American River redd surveys and associated monitoring from 2002 through 2007 indicate that only a few hundred steelhead spawn in the river and the majority of those spawners originated from Nimbus Hatchery (Hannon and Deason 2008).

In analyzing flow-habitat relationships for anadromous salmonids in the upper Sacramento River upstream of the Battle Creek confluence and downstream of Keswick Dam, USFWS (2003) reported that it was not possible to differentiate between steelhead and resident rainbow trout. Specific information regarding steelhead spawning within the mainstem Sacramento River is limited due to lack of monitoring (NMFS 2004). Currently, the number of steelhead spawning in the Sacramento River is unknown because redds cannot be distinguished from a large resident rainbow trout population that has developed as a result of managing the upper Sacramento River for coldwater species.

2.3.5 Critical Habitat

When designating critical habitat, NMFS focuses on "Primary Constituent Elements" (PCEs), which are the principal biological or physical constituent elements within the defined area that are essential to the conservation of the listed species (50 CFR 424.12(b)). PCEs considered essential for the conservation of the California Central Valley steelhead DPS are those sites and habitat components that support one or more life stages (50 CFR 226.211(c)), including:

- ☐ Freshwater spawning sites with water quantity and quality conditions and substrate supporting spawning, incubation and larval development.

- ☐ Freshwater rearing sites with water quantity and floodplain connectivity to form and maintain physical habitat conditions and support juvenile growth and mobility; water quality and forage supporting juvenile development; and natural cover such as shade, submerged and overhanging large wood, log jams and beaver dams, aquatic vegetation, large rocks and boulders, side channels, and undercut banks.

- ☐ Freshwater migration corridors free of obstruction and excessive predation with water quantity and quality conditions and natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, side channels, and undercut banks supporting juvenile and adult mobility and survival.

- ☐ Estuarine areas free of obstruction and excessive predation with water quality, water quantity, and salinity conditions supporting juvenile and adult physiological transitions between fresh- and saltwater; natural cover such as submerged and overhanging large wood, aquatic vegetation, large rocks and boulders, and side channels; and juvenile and adult forage, including aquatic invertebrates and fishes, supporting growth and maturation.

NMFS proposed[5] critical habitat for Central Valley steelhead on December 10, 2004 (69 FR 71880) and published a final rule designating critical habitat for this species on September 2, 2005 (70 FR 52488). **Figure 2-10** depicts the designated critical habitat and distribution for Central Valley steelhead.

2.3.6 Reasons for Listing

Section 4 of the ESA requires the Secretary of the Interior or Commerce, depending upon the species involved, to determine if any species is an endangered or threatened species for any of the following listing factors: (1) present or threatened destruction, modification or curtailment of its habitat or range; (2) overutilization for commercial, recreational. scientific or educational purposes; (3) disease or predation; (4) inadequacy of existing regulatory mechanisms; or (5) other natural or manmade factors affecting its continued existence. Each of these listing factors with respect to Central Valley steelhead are summarized below.

The Present or Threatened Destruction, Modification, or Curtailment of Central Valley Steelhead's Habitat or Range.

The widespread degradation, destruction, and blockage of freshwater habitats within the Central Valley, and the continuing impacts to habitat resulting from water management were identified as key reasons why Central Valley steelhead were listed under the ESA (61 FR 41541, August 9, 1996; 63 FR 13347, March 19, 1998). These reasons are briefly discussed below under two categories – (1) habitat loss, and (2) habitat degradation.

<u>Habitat Loss</u>

About 80% of habitat identified by the TRT that was historically available to anadromous *O. mykiss* is now behind impassable dams, and 38% of the populations identified by the TRT have lost all of their habitat (Lindley *et al.* 2006). Anadromous *O. mykiss* populations may have been extirpated from their entire historical range in the San Joaquin Valley and most of the larger basins of the Sacramento River. The roughly 52% of watersheds with at least half of their historical area below impassable dams are all small, low elevation systems (Lindley *et al.* 2006).

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[5] NMFS proposed critical habitat for Central Valley steelhead on February 5, 1999 (64 FR 5740) in compliance with Section 4(a)(3)(A) of the ESA, which requires that, to the maximum extent prudent and determinable, NMFS designates critical habitat concurrently with a determination that a species is endangered or threatened (NMFS 1999). On February 16, 2000 (65 FR 7764), NMFS published a final rule designating critical habitat for Central Valley steelhead. Critical habitat was designated to include all river reaches accessible to listed steelhead in the Sacramento and San Joaquin rivers and their tributaries in California. Also included were river reaches and estuarine areas of the Delta, all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait, all waters of San Pablo Bay westward of the Carquinez Bridge, and all waters of San Francisco Bay (north of the San Francisco/Oakland Bay Bridge) from San Pablo Bay to the Golden Gate Bridge.

In response to litigation brought by the National Association of Homebuilders (NAHB) (NAHB v. Evans, 2002 WL 1205743 No. 00–CV–2799 (D.D.C.)), NMFS sought judicial approval of a consent decree withdrawing critical habitat designations for 19 Pacific salmon and *O. mykiss* ESUs. The District Court in Washington DC approved the consent decree and vacated the critical habitat designations by Court order on April 30, 2002 (NAHB v. Evans, 2002 WL 1205743 (D.D.C. 2002)).

Habitat Degradation

The habitat in the Central Valley that remains accessible to anadromous *O. mykiss* has been drastically altered and degraded. Reynolds *et al.* (1993) reported that declines in Central Valley steelhead stocks are *"due mostly to water development, inadequate instream flows, rapid flow fluctuations, high summer water temperatures in streams immediately below reservoirs, diversion dams which block access, and entrainment of juveniles into unscreened or poorly screened diversions."* Other problems related to land use practices (agriculture and forestry) and urbanization also have certainly contributed to the decline of Central Valley steelhead (McEwan 2001).

Overutilization of Steelhead for Commercial, Recreational, Scientific, or Educational Purposes

The overutilization of Central Valley steelhead was not identified as an important reason for the species' listing (61 FR 41541; 63 FR 13347).

Commercial or Recreational Fishery Impacts on Central Valley Steelhead

Because there is no commercial fishery for Central Valley steelhead and the recreational fishery is regulated to protect wild steelhead, there is some reason to think that fishing impacts would not be a significant problem for this species. However, because the sizes of Central Valley steelhead populations are largely unknown, it is difficult to make conclusions about the impact of the recreational fishery (Good *et al*. 2005).

Scientific or Educational Utilization of Central Valley Steelhead

NMFS issues permits under the ESA for scientific research that stipulate specific conditions to minimize take of steelhead. These permitted studies provide information about steelhead in the Central Valley that is useful for management and conservation of the DPS and are not considered a factor for the decline of this species (NMFS 2011c).

Disease or Predation

Disease

Infectious disease is one of many factors which can influence adult and juvenile steelhead survival. Steelhead are exposed to numerous bacterial, protozoan, viral, and parasitic organisms in spawning and rearing areas, hatcheries, migratory routes, and the marine environments. Specific diseases such as bacterial kidney disease (BKD), ceratomyxosis, columnaris, Furunculosis, infectious hematopoietic necrosis (IHNV), redmouth and black spot disease, Erythrocytic Inclusion Body Syndrome (EIBS), and whirling disease among others are present and are known to affect steelhead and salmon (NMFS 1996).

Although disease was recognized as a potential factor in the decline of west coast steelhead (NMFS 1996), it was not specifically identified as an important reason why Central Valley steelhead were listed under the ESA (61 FR 41541; 63 FR 13347).

The Inadequacy of Existing Regulatory Mechanisms

The inadequacy of existing regulatory mechanisms was not identified as a key factor in the listing of Central Valley steelhead. Although there is a lengthy discussion of this listing factor in the Final Rule listing Central Valley steelhead as threatened, most of the discussion applies to other steelhead ESUs, which were also considered for listing at that time (63 FR 13347).

Other Natural or Manmade Factors Affecting the Continued Existence of Central Valley Steelhead

Hatchery Management/Reduced Genetic Integrity

Along with habitat loss and habitat degradation, hatchery management was identified as a key factor in the listing of Central Valley steelhead (61 FR 41541; 63 FR 13347). Over the past several decades, the genetic integrity of Central Valley steelhead has been diminished by increases in the proportion of hatchery fish relative to naturally produced fish, the use of out-of-basin stocks for hatchery production, and straying of hatchery produced fish (CDFW and NMFS 2001; California Hatchery Scientific Review Group 2012). Four hatcheries in the Central Valley produce steelhead, and each hatchery has specific production targets, as identified in Table 2-5. Currently there is still great concern about the ecological and genetic impacts of steelhead hatchery management in the Central Valley (California Hatchery Scientific Review Group 2012). These concerns continue to be related to the proportion of hatchery fish relative to naturally produced fish, the predominance of Eel River steelhead genetics in the Nimbus Hatchery steelhead program, and straying of hatchery produced steelhead.

Potential adverse effects to wild steelhead populations associated with hatchery production are similar to those described above for winter-run Chinook salmon. Research has indicated that approximately 63 to 92 percent of steelhead smolt production is of hatchery origin (NMFS 2003). Overall, hatchery-origin fish appear to comprise the majority of the DPS (Lindley *et al*. 2007)

Habitat fragmentation and population declines resulting in small, isolated populations also pose genetic risk from inbreeding, loss of rare alleles, and genetic drift.

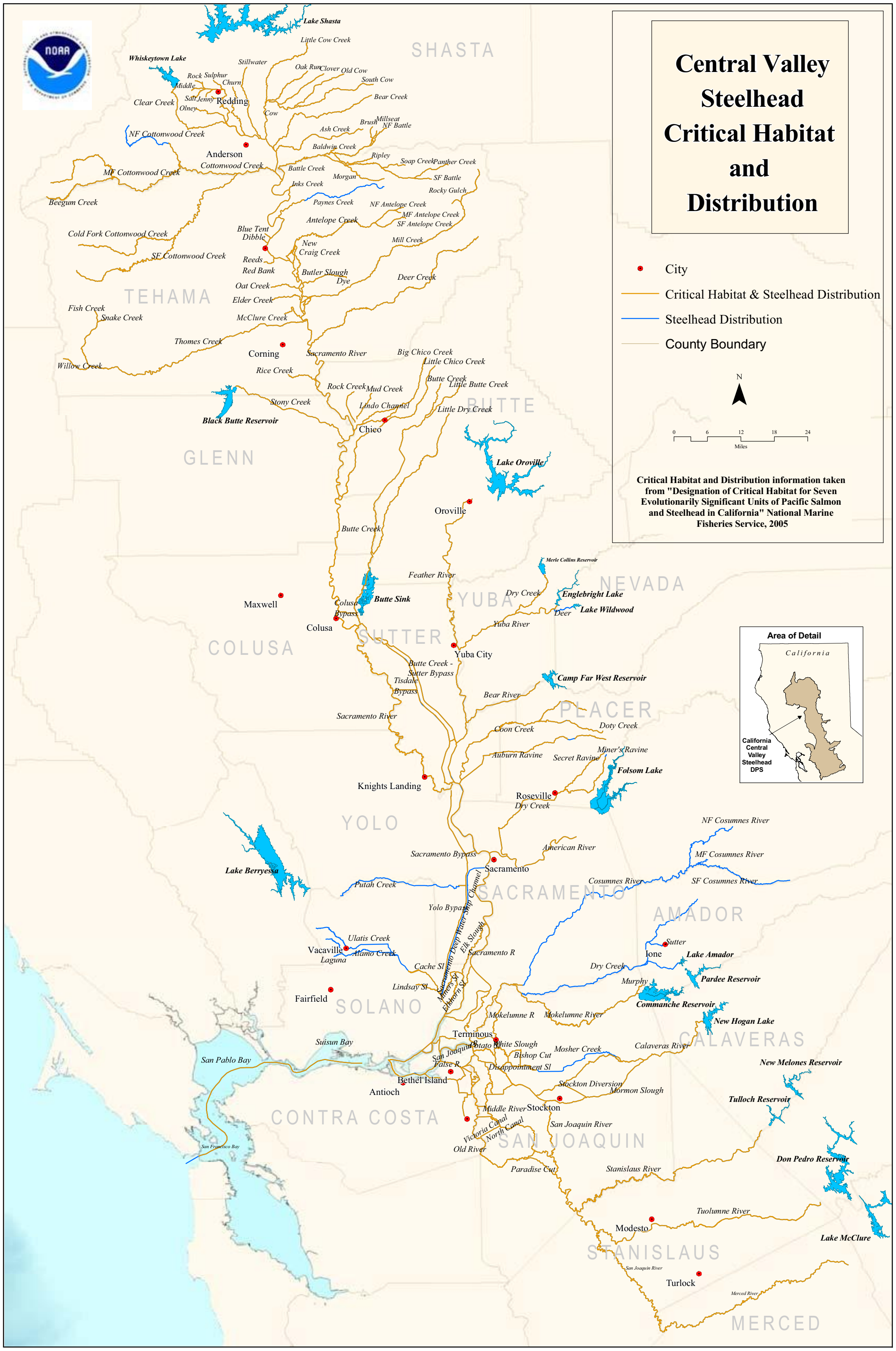

Figure 2-10. Central Valley Steelhead Designated Critical Habitat and Distribution

Table 2-5. Annual Steelhead Production Targets for Central Valley Hatcheries

Hatchery	Production Target
Coleman National Fish Hatchery	600,000
Feather River Fish Hatchery	500,000
Nimbus Hatchery	430,000
Mokelumne Fish Hatchery	100,000

There is still significant local genetic structure to Central Valley steelhead populations. Hatchery effects appear to be localized – for example, Feather River and the FRFH steelhead are closely related, as are American River and Nimbus Hatchery fish (DWR 2002). The Coleman National Fish Hatchery steelhead program was derived from the endemic stock of steelhead in the upper Sacramento River. Early-returning (October – December) steelhead in Battle Creek are similar genetically to the Coleman NFH adults and late-returning (March –May) natural-origin steelhead in Battle Creek are similar genetically to mainstem Sacramento River steelhead (Capton *et al*. 2004).

In general, although genetic structure was found, all naturally-spawned *O. mykiss* populations within the Central Valley basin were closely related, regardless of whether they were sampled above or below a known barrier to anadromy. This is due to some combination of pre-impoundment historic shared ancestry, downstream migration and, possibly, limited, anthropogenic upstream migration. However, lower genetic diversity in above-barrier populations indicates a lack of substantial genetic input upstream and highlights lower effective population sizes for above-barrier populations. Above-barrier populations clustered with one another and below-barrier populations are most closely related to populations in far northern California, specifically the genetic groups that include the Eel and Klamath rivers. Since Eel River origin broodstock were used for many years at Nimbus Hatchery on the American River, it is likely that Eel River genes persist there and have also spread to other basins by migration, and that this is responsible for the clustering of the below-barrier populations with northern California ones. This suggests that the below-barrier populations in this region appear to have been widely introgressed with hatchery fish from out of basin broodstock sources. The consistent clustering of the above-barrier populations with one another, and their position in the California-wide trees, indicate that they are likely to most accurately represent the ancestral population genetic structure of steelhead in the Central Valley (Garza and Pearse 2008).

A significant transfer of genetic material has occurred among hatcheries within the Central Valley, as well as some transfer from systems outside the Central Valley. For example, an Eel River strain of steelhead was used as the founding broodstock for the Nimbus Hatchery (DWR 2002). Additionally, eyed eggs from the Nimbus Hatchery were transferred to the FRFH several times in the late 1960s and early 1970s (DWR 2002). There have also been transfers of steelhead from the FRFH to the Mokelumne Hatchery. In the late 1970s, a strain of steelhead was brought in from Washington State for the FRFH (DWR 2002).

Environmental Variability

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

El Nino events and periods of poor ocean 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. Alternatively, periods of favorable ocean conditions can offset the poor condition of inland habitats and result in increased population abundance and productivity by increasing the size and correlated fecundity of returning adults (NMFS 1996).

2.3.7 Threats Assessment

A detailed threats assessment was conducted for the California Central Valley steelhead DPS, and followed the same general procedure previously described for winter-run Chinook salmon. The threats/stressors affecting each steelhead diversity group and population are described by life stage in Appendix B.

Some major stressors to the entire California Central Valley steelhead DPS include passage impediments and barriers, warm water temperatures for rearing, hatchery effects, limited quantity and quality of rearing habitat, predation, and entrainment. The complete prioritized list of life stage-specific stressors to the DPS is presented in Appendix B.

Many of the most important stressors specific to the steelhead diversity groups correspond to the diversity group-specific stressors described for the Central Valley spring-run Chinook salmon ESU in section 2.2.7. The only diversity group (i.e., area) unique to the California Central Valley steelhead DPS, relative to the diversity groups in the Central Valley spring-run Chinook salmon ESU is the southern Sierra Nevada diversity group. Some of the most important stressors to steelhead in the southern Sierra Nevada diversity group include:

- ❑ Friant Dam blocking access to habitat historically used by San Joaquin River steelhead;
- ❑ Passage impediments on Calaveras River including Bellota Weir and flash board dams;
- ❑ Limited habitat availability in each watershed and in the mainstem San Joaquin River for spawning and juvenile rearing;
- ❑ La Grange and Don Pedro dams blocking access to habitat historically used by Tuolumne River steelhead;
- ❑ Goodwin and New Melones dams blocking access to habitat historically used by Stanislaus River steelhead;
- ❑ McSwain and Crocker Huffman dams blocking access to habitat historically used by Merced River steelhead;
- ❑ Camanche and Pardee dams blocking access to habitat historically used by Mokelumne River steelhead;
- ❑ Entrainment at the Jones and Banks Pumping Plants and associated losses from predation; and
- ❑ Inadequate summer flow on the Tuolumne River.

2.3.8 Conservation Measures

Conservation measures that have been taken to improve habitat for steelhead include, activities under the Clear Creek Restoration Program, the Battle Creek Salmon and Steelhead Restoration Project, several actions taken by the AFRP and the ERP, the Lower Yuba River Habitat Restoration Project, and actions under the San Joaquin River

Restoration Program. Specific information on how each of these programs and projects has benefited steelhead is described in the 5-year status review published in 2011 (NMFS 2011c).

Other ongoing measures to protect steelhead in the State of California include 100 percent adipose fin-clipping of all hatchery steelhead, although they are not coded-wire tagged and, therefore, determination of hatchery of origin, as well as straying rates, remain problematic for stock identification.

The State also works closely with NMFS to review and improve inland fishing regulations. As a result, zero bag limits for unmarked steelhead, gear restrictions, closures, and size limits designed to protect smolts are additional inland harvest measures that protect Central Valley steelhead.

While some conservation measures have been successful in improving habitat conditions for Central Valley steelhead, access to historic habitat remains blocked in many cases and fundamental problems still remain with the quality of the species' remaining habitat (see Lindley *et al*. 2009 and Cummins *et al*. 2008) and it continues to be highly degraded. The loss of historical habitat and the degradation of remaining habitat both continue to be major threats to this DPS.

3.0 Recovery Strategy

> *"The wide-ranging migration patterns and unique life histories of anadromous salmonids take them across ecosystem and management boundaries in an increasingly fragmented world, which creates the need for analyses and strategies at similarly large scales."*
>
> - Good *et al.* 2007. Recovery Planning for Endangered Species Act-listed Pacific Salmon: Using Science to Inform Goals and Strategies

3.1 INTRODUCTION

A broad strategic framework is necessary to serve as a strategic planning guide to integrate the actions contributing to the overarching goal of recovery of the two Chinook salmon ESUs and the steelhead DPS, which contain a mixture of hatchery and wild fish, and resident and anadromous fish. To address the complexity associated with the multi-faceted considerations for recovery efforts within the Central Valley Domain, San Francisco Estuary, and Pacific Ocean, this recovery strategy: explains the connection between the biological needs and situational background of the ESUs/DPS and the recovery program; and, presents the most effective means to achieve the individual recovery criteria and objectives, and, in turn, the delisting of the ESUs/DPS.

This chapter describes where we want to get to in terms of the number and spatial distribution of viable and dependent populations. Eliminating differences between the current viability and the desired viability is at the core of the recovery strategy. Having a strong rationale for, and understanding of, what a recovered Central Valley ESU/DPS will look like is critical to developing an effective strategy.

To convey this rationale and understanding, the chapter first describes the key facts and assumptions upon which the recovery plan is based. These facts and assumptions cover salmonid conservation principles, recovery implementation principles, and specific watershed classifications for recovery. Next, the primary objectives of the recovery plan are described. Lastly, adaptive management and monitoring are discussed because both will play a critical role in recovering the Chinook salmon ESUs and steelhead DPS.

3.2 FACTS AND ASSUMPTIONS

3.2.1 Salmonid Conservation Principles

Recovery of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead across such vast and altered ecosystems as the Central Valley, the San Francisco Estuary, and the Pacific Ocean, will require a broadly focused, science-based strategy. The scientific rationale for the strategy in this plan focuses on two key salmonid conservation principles. The first is that functioning, diverse, and interconnected habitats are necessary for a species to be viable.

That is, we cannot achieve salmon and steelhead recovery without providing sufficient habitat. Anadromous salmonids persisted in the Central Valley for thousands of years because the available habitat capacity and diversity allowed species to withstand and adapt to environmental changes including catastrophes such as prolonged droughts, large wildfires, and volcanic eruptions. The second salmonid conservation principle guiding the recovery strategy is that a species' viability is determined by its spatial structure, diversity, productivity, and abundance (McElhany *et al*. 2000). Life history diversity, genetic diversity, and metapopulation organization are ways that salmonids adapt to their complex and connected habitats. These factors are the basis of salmonid productivity and contribute to the ability of salmonids to cope with environmental variation that is typical of freshwater and marine environments.

Habitat Capacity and Diversity

A purpose of the ESA is to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved, so that these species no longer require the protections of the ESA (i.e., can be delisted).

The availability and quality of habitat is fundamental to species viability; viable ESUs/DPSs and populations require a network of complex and interconnected habitats that are created, altered, and maintained by natural physical processes in freshwater, the estuary, and the ocean. Restoration of Central Valley anadromous salmonids must address the entire natural and cultural ecosystem, which encompasses the continuum of freshwater, estuarine, and ocean habitats where salmonid fishes complete their life histories. This consideration includes human developments, as well as natural habitats.

These diverse and high-quality habitats, which have been extensively degraded by human activities, are crucial for salmonid spawning, rearing, migration, maintenance of food webs, and predator avoidance. Ocean conditions, which are variable, are important in determining the overall patterns of productivity of salmon populations.

Unfortunately, habitat for Central Valley salmonids has been extensively altered. Dams have disconnected fish from their historic habitats and altered flow regimes downstream by storing winter and spring runoff and releasing higher–than-historic flows during summer for agricultural and municipal uses. More than 1,600 miles of levee construction in the Central Valley have constricted river channels, disconnected floodplains from active river channels, reduced riparian habitat, and reduced natural channel function, particularly in the Delta and the lower reaches of the Sacramento and San Joaquin Rivers. Thousands of water diversions within the Central Valley reduce instream flows, and the state and federal pumping facilities in the south Delta reverse natural river flows, disrupt natural tidal patterns, and alter the migration patterns and survival of salmonid individuals and populations.

Habitat conservation and enhancement efforts should focus on the sites and areas identified in NMFS's critical habitat designations for each of the three species. Additionally, consideration should be given to the PCEs and other relevant habitat conditions as summarized below.

<u>Freshwater Spawning Sites</u>

- have good water quality and quantity
- have substrate for spawning, incubation, and larval development

Freshwater Rearing Sites

- have good water quality and quantity and floodplain connectivity to maintain habitat conditions
- have forage for juvenile development
- have natural cover to provide refuge (such as submerged and overhanging large wood, log jams, beaver dams, aquatic vegetation, large rocks or boulders, side channels, undercut banks, etc.)

Freshwater Migration Corridors

- are unobstructed
- have good water quality and quantity
- have natural cover to provide refuge to support juvenile and adult mobility and survival
- afford safe passage conditions for migrations

Estuarine Areas

- are unobstructed
- have good water quality and quantity, with salinity conditions to support juvenile and adult physiological transitions between freshwater and saltwater
- have natural cover to provide refuge to support migrations among systems
- have forage for juvenile and adult migrating fish
- are free from overabundance of non-native predators

Nearshore Marine Areas[6]

- are unobstructed
- have good water quality and quantity conditions
- have forage to support growth and maturation of fish
- have natural cover to provide refuge

Offshore Marine Areas[6]

- have good water quality conditions
- have prey to support growth and maturation

Population Viability

Recovery planning seeks to ensure the viability of protected species. In the short term, viability of populations (and ESU/DPS) depends on the demographic properties of the population or ESU/DPS, such as population size, growth rate, the variation in growth rate, and carrying capacity (Tuljapurkar and Orzack 1980), all of which depend largely on the quality and quantity of habitat. In the longer term, genetic diversity, and the diversity of habitats that support genetic diversity, become increasingly important (McElhany

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[6] For winter-run Chinook salmon marine areas are not explicitly included as physical biological features in the final rule designating critical habitat for that ESU (58 FR 33212; June 16, 1993); however, marine areas are important as the species spends the majority of its life cycle in the ocean. The preamble to the final rule designating critical habitat for CV spring-run Chinook salmon and CV steelhead discussed marine areas as primary constituent elements for the ESUs addressed in the final rule (70 FR 52488, 52521; September 2, 2005); however, the final rule did not include marine areas as primary constituent elements for CV spring-run Chinook salmon and CV steelhead (50 CFR 226.211(c); 70 FR 52488, 52537, September 2, 2005), and there are no marine areas designated as critical habitat for these species..

et al. 2000; Kendall and Fox 2002; Williams and Reeves 2003).

NMFS has developed guidelines to apply the four Viability of Salmon Population (VSP) parameters (abundance, productivity, spatial structure, and diversity). Application of the guidelines determines whether or not a population is viable (McElhany *et al.* 2000). The four parameters and their associated attributes are presented in **Figure 3-1.** The rationale applies these factors to define viable populations.

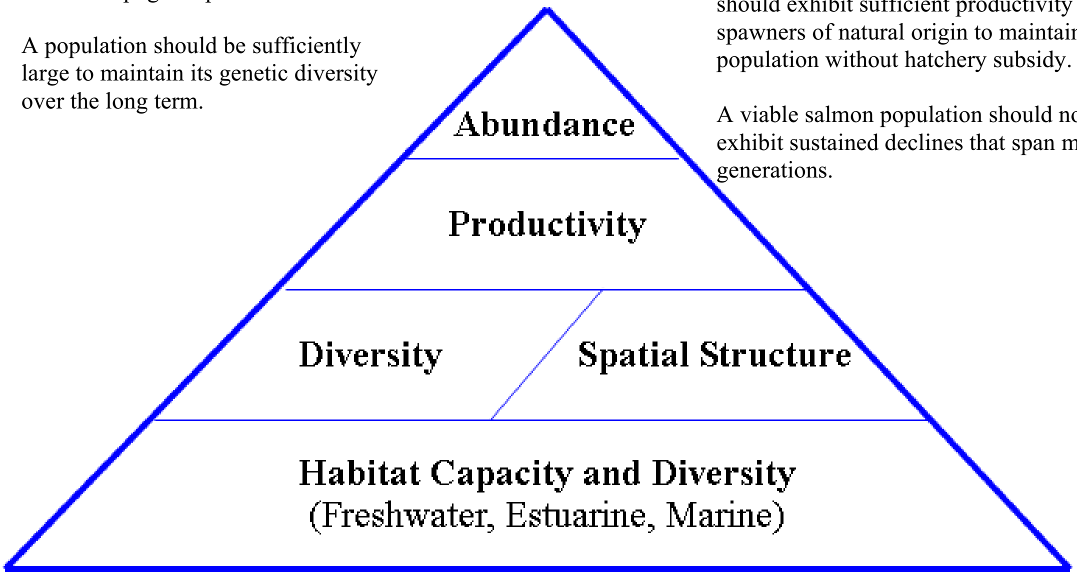
As presented in Good *et al.* (2005), criteria for VSP are based on population characteristics that reasonably predict extinction risk and reflect processes important to populations. Abundance is critical, because small populations are generally at greater risk of extinction than large populations. Stage-specific or lifetime productivity (i.e., population growth rate) provides information on important demographic processes. Abundance and productivity data are used to assess the status of populations of threatened and endangered ESUs (Good *et al.* 2005). Genotypic and phenotypic diversity are important in that they allow species to use a wide array of environments, respond to short-term changes in the environment, and survive long-term environmental change. Spatial structure reflects how abundance is distributed among available or potentially available habitats.

ABUNDANCE
A population should be large enough to have a high probability of surviving environmental variation of the patterns and magnitudes observed in the past and expected in the future.
A population should have sufficient abundance for compensatory processes to provide resilience to environmental and anthropogenic perturbation.

A population should be sufficiently large to maintain its genetic diversity over the long term.

PRODUCTIVITY (POPULATION GROWTH RATE)
Natural productivity should be sufficient to reproduce the population at a level of abundance that is viable.
Productivity should be sufficient throughout freshwater, estuarine, and nearshore life stages to maintain viable abundance levels, even during poor ocean conditions.
A viable salmon population that includes naturally spawning hatchery-origin fish should exhibit sufficient productivity from spawners of natural origin to maintain the population without hatchery subsidy.

A viable salmon population should not exhibit sustained declines that span multiple generations.



DIVERSITY

Human-caused factors such as habitat changes, harvest pressures, artificial propagation, and exotic species introduction should not substantially alter variation in traits such as run timing, age structure, size, fecundity (birth rate), morphology, behavior, and genetic characteristics.
The rate of gene flow among populations should not be altered by human caused factors.

Natural processes that cause ecological variation should be maintained.

SPATIAL STRUCTURE

Habitat patches should not be destroyed faster than they are naturally created.
Human activities should not increase or decrease natural rates of straying among salmon sub-populations.
Habitat patches should be close enough to allow the appropriate exchange of spawners and the expansion of population into underused patches.

Some habitat patches may operate as highly productive sources for population production and should be maintained.

Due to the time lag between the appearance of empty habitat and its colonization by fish, some habitat patches should be maintained that appear to be suitable, or marginally suitable, even if they currently contain no fish.

Figure 3-1. Viable salmonid population (VSP) parameters and their attributes. The quality and diversity of habitat (habitat capacity and diversity) available to the species in each of its three main habitat types (freshwater, estuarine and marine environments) are critical factors to VSP.

ESU Viability

Good *et al.* (2007) reported that viability of Pacific salmon ESUs depends on the status and distribution of populations within the entire ESU. In general, the ESU is more likely to be viable if it contains multiple populations (metapopulations), some of which meet viability criteria. Viability of the ESU is also more likely if: (1) populations are geographically widespread but some are close enough together to facilitate connectivity; (2) populations do not all share common catastrophic risks; and (3) populations display diverse life-histories and phenotypes (McElhany *et al.* 2000).

Considerations regarding ESU viability are discussed in ISAB (2005), and are generally adopted herein for application to the two Chinook salmon ESUs and the steelhead DPS in the Central Valley Domain. To be viable, an ESU needs more than simple persistence over time; it needs to be in an ecologically and evolutionarily functional state. Evaluation of ESU viability depends not only on the numbers of component populations and the abundance and productivity of those individual populations, but also on the integration of population dynamics within the ecosystem as a whole. For an ESU to fulfill the entire complement of ecological and evolutionary interactions and functions (ISAB 2005), it needs to contain viable populations inhabiting a variety of different habitats, interconnected as a metapopulation.

A viable ESU consists of a group of populations existing as a metapopulation that is self-sustaining for the foreseeable future. Populations within a viable ESU need to exhibit the abundance, productivity, diversity, and spatial distribution of natural spawners, sufficient to accomplish the following: avoid the loss of genetic and/or life history diversity during short-term reductions in abundance that are expected parts of environmental cycles; fulfill key ecological functions that are attributable to the species, such as nutrient cycling and food web roles; and provide for long-term evolutionary adaptability to changing environmental conditions.

This Recovery Plan endeavors to avoid loss of currently small, peripheral, or in any way seemingly less-valuable populations. The importance of these populations is not well understood, but it is likely they contribute significantly to ESU and DPS scale viability by providing increased life history diversity. They also are likely to buffer against local catastrophic occurrences.

In addition to the considerations presented by ISAB (2005), the Central Valley TRT addressed ESU viability for the Central Valley Domain, using two other approaches. The goal of these two approaches is to distribute risk and maximize future potential for adaptation.

In the first approach, the Central Valley TRT assessed ESU viability by examining the number and distribution of viable populations across the landscape, and their proximity to sources of catastrophic disturbance. Risk-spreading examines how viable populations are distributed among geographically-defined regions within an ESU. For example, the Puget Sound, Willamette/Lower Columbia and Interior Columbia TRTs have used the idea of dividing ESUs into subunits (Myers *et al.* 2003; Ruckelshaus *et al.* 2002; Interior Columbia Basin Technical Recovery Team 2003), and of requiring population presence and redundancy in the subunits (The Central Valley TRT referred to this approach as the "representation and redundancy" rule). ESU subunits are intended to capture geographically important components of habitat, life history, or genetic diversity that contribute to the viability of salmonid ESUs (Hilborn *et al.* 2003; Bottom *et al.* 2005).

In practice, this approach holds that if extinction risks are not strongly correlated, two populations, each with low risk of extinction, would be extremely unlikely to go extinct simultaneously (McElhany *et al.* 2003). Should a catastrophic event cause one of the populations to go extinct, the other(s) could serve as a source of colonists to re-establish the extirpated population.

In the second approach, the TRT attempted to account explicitly for the spatial structure of the ESU and the spatial structure of various catastrophic risks, including volcanoes, wildfires, and droughts. The product of this approach is a set of diversity groups. A diversity group is a geographically-distinct portion of the ESU/DPS which is ecologically or otherwise identifiable and which is essential to the recovery of the entire listed entity (e.g., to conserve genetic robustness, demographic robustness, and important life history stages).

To meet the objective of representation and redundancy, diversity groups need to contain multiple populations to survive in a dynamic ecosystem subject to unpredictable stochastic events, such as pyroclastic events or wild fires.

As discussed in Lindley *et al.* (2004), the Central Valley Basin is characterized by a wide range of climatological, hydrological, and geological conditions. The Central Valley TRT used the Jepson floristic ecoregions defined by Hickman (1993) as a starting point for salmon ecoregions, but modified them to account for geologic characteristics that produce spring-dominated base flow. Such conditions strongly influence salmonid habitat, but not upland plants. The resulting ecoregions for salmon and steelhead consider geology and are referred to herein as "Diversity Groups".

Delineation of Recovery Units

The four diversity groups listed below serve as recovery units, in that each one that was historically occupied by a species is essential for the recovery of that species. The diversity group structure is presented in **Figure 3-2** for the Chinook salmon ESUs and in **Figure 3-3** for the steelhead DPS in the Central Valley Domain.

The Central Valley Domain Diversity Groups are:

The **basalt and porous lava diversity group** composed of the upper Sacramento River (including watersheds upstream of Shasta Dam), Cow Creek and Battle Creek watersheds

The **northwestern California diversity group** composed of streams that enter the mainstem Sacramento River from the northwest, such as Clear Creek

The **northern Sierra Nevada diversity group** composed of streams tributary to the Sacramento River from the east, from Antelope Creek to the Mokelumne River, and

The **southern Sierra Nevada diversity group** composed of streams tributary to the San Joaquin River from the east.

The diversity groups reflect the historic distribution of each species. As a result, the number (and geographic range) of diversity groups differs by species. For winter-run Chinook salmon, all populations required for recovery are located in a single diversity group. This is the northernmost area called the "basalt and porous lava" diversity group. This recovery unit includes the streams that historically supported winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. All of these streams receive large inflows of cold water from springs throughout the summer, upon which winter-run Chinook salmon depend. This region includes part of the upper Sacramento drainage (currently blocked by Shasta Dam), part of the Modoc Plateau region, and extends south to the Battle Creek watershed.

Three additional recovery units have been identified for spring-run Chinook salmon and steelhead. Though the southern part of the Cascades region (i.e., the drainages of Mill, Deer and Butte creeks) also contain some geology that results in spring-fed baseflows, these streams are included in the northern Sierra Nevada diversity group. The Sierra Nevada watersheds are divided into northern and southern diversity groups (split at the Mokelumne River watershed). This division reflects the greater importance of snowmelt runoff in the southern Sierra, and also places tributaries to the Sacramento and San Joaquin rivers in different diversity groups. The fourth diversity group includes tributaries that drain the watersheds on the west side of the northern Sacramento watershed and extends from Shasta Dam in the north to Willow Creek and Black Butte Reservoir in the south.

Lindley *et al.* (2006) report that historically steelhead populations were located in tributaries to Suisun Bay and to the San Joaquin River from the west (i.e., Central Western California diversity group). Recovery of Central Valley steelhead can be achieved without the presence of populations in either the Suisun Bay or Central Western California diversity groups. This conclusion is based on the fact that the four Chinook salmon diversity groups, which did not include the Suisun Bay or Central Western California regions, supported abundant and diverse Chinook salmon populations for thousands of years. As such, the extent and diversity of habitats historically available in those four diversity groups would likely also support a viable steelhead DPS, if the quantity and quality of habitat currently available in those regions was sufficiently increased. Additionally, based on the quantity and quality of available steelhead habitat, the Central Western California diversity group, which drains the relatively low elevation watersheds along the west side of the San Joaquin River, likely contributed little to the abundance of Central Valley steelhead. The Sacramento River basin was the source of most steelhead production (Lindley *et al.* 2006).

Because recovery can be reached without them, the Suisun area and the Central Western California diversity groups are not considered to be steelhead recovery units in this plan.

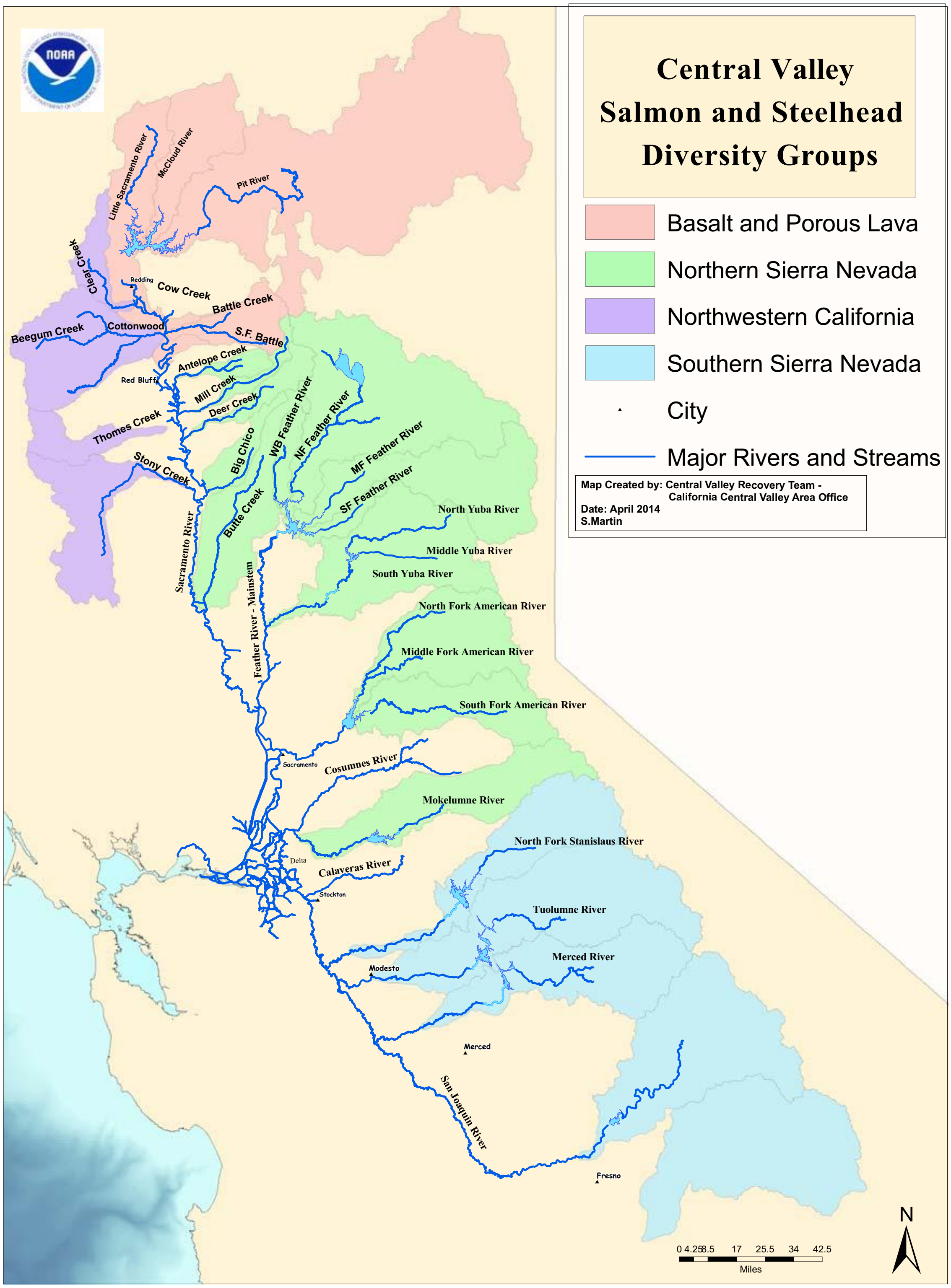


Figure 3-2. Diversity Groups for the Sacramento River Winter-run Chinook salmon and Central Valley Spring-run Chinook salmon ESUs in the Central Valley Domain. The Sacramento River Winter-run Chinook Salmon ESU Historically Occurred in the Basalt and Porous Lava Diversity Group, while Spring-run Chinook Salmon Occurred in all of the Diversity Groups Shown.

Figure 3-3. Diversity Groups for the California Central Valley Steelhead DPS in the Central Valley Domain.

3.2.2. Recovery Implementation Principles

The Strategy is based on five foundational implementation principles. The principles take into account the magnitude of the actions required by the strategy and the significant investment of resources required. Success is dependent on actions throughout the range of the species, in freshwater, estuarine, and ocean habitats and will require public understanding and support. Key elements in sustaining public support are investing in the most cost-effective practices, and continually assessing and reporting recovery plan progress and effectiveness. The five principles are described briefly below.

System wide Approach

Because the listed species are wide-ranging, and depend on headwater, riverine, estuarine, and ocean habitats, recovery implementation should address this entire set of ecosystems.

Cost Effectiveness

To focus investments on those actions with the highest likelihood of success, implementation of the strategy should give priority to measures with a proven record of success within the ESUs and DPS, or in ecologically comparable environments. Prior to initiating actions, similar actions previously implemented in the ESUs or DPS should be reviewed for lessons learned. It will also be beneficial to review the success of actions undertaken in other locations.

Self-Sustaining Improvements

Due to the uncertainty of future budgets, priority will be given to measures that, once implemented, are self-sustaining. In cases in which necessary actions will need maintenance (e.g., reintroductions into habitat upstream of impassible dams), priority will be given to options that need the least intervention in the long term.

Stakeholder Cooperation and Public Support

Partnerships and collaboration between all stakeholders and regulatory agencies are necessary to accelerate actions, increase available resources, reduce duplication of effort, encourage innovative solutions, improve communication, and increase public involvement and support through shared authority and ownership of habitat restoration (USFWS 2001). The Department of the Interior AFRP and the ERP contain processes for building partnerships to pursue restoration actions. The AFRP and the ERP continue to build partnerships and provide funds to local agencies and watershed groups, as well as other Federal and State agencies, in order to implement specific restoration actions throughout the Central Valley Domain. NMFS is engaged in both of these efforts, as well as with local agency and stakeholder efforts.

NMFS recognizes the high cost, broad geographic scope, and the economic, social, and cultural implications of necessary actions. NMFS therefore encourages local agencies and stakeholder groups to share or lead implementation of recovery and habitat restoration actions within the Central Valley Domain, and views such involvement as essential to success of the Recovery Plan.

In addition to participation by local, state and other Federal agencies, public support is necessary for the acceptance and successful implementation of the Recovery Plan for the Central Valley Domain. As stated by USFWS (2001), public sentiment is an indicator of perceived economic and social effects of restoration actions, and public support for an action will facilitate implementation and attract partners for future actions. NMFS will continue to coordinate with public stakeholders to assist in identifying, planning, and implementing recovery actions.

Adaptive Management and Monitoring

The plan will incorporate adaptive management into all components and actions. The reduced distribution and abundance of the listed species necessitates immediate action, but some key data gaps exist. Incorporating effective monitoring into plan actions will assist in addressing data needs and in modifying recovery actions where necessary. Effective monitoring, evaluation, and reporting will also provide for accountability.

Recovery Plan implementation includes an adaptive management and monitoring component to increase the effectiveness of, and to address the scientific uncertainty associated with specific restoration actions. The adaptive management component allows NMFS, as well as local water agencies and irrigation districts, municipal and county governmental agencies, watershed groups, and state and other Federal agencies, to learn from past experiences and to alter actions based on their measured effectiveness. There will be a thorough review of the effectiveness of the recovery actions implemented, as reflected by population and habitat condition responses, at the 5-year status reviews of the Chinook salmon ESUs and the steelhead DPS.

Within the framework of the Recovery Plan, NMFS has the flexibility to work with partners. This includes support in developing and implementing recovery actions that address specific problems as they arise or intensify. As additional information becomes available regarding threats abatement, the links between threats and population responses, and the viability of Chinook salmon and steelhead in the Central Valley Domain, specific measures as well as the plan itself will be modified. The adaptive management and monitoring component provides a framework to obtain the appropriate types and amounts of data to evaluate the effectiveness of recovery actions and the progress toward recovery. Therefore, the adaptive management and monitoring program needs to address system-wide, watershed, population, and action-specific scales. The program is outlined in greater detail in at the end of this chapter in section 3.4.

3.2.3 Watershed Classifications (Core 1, 2, or 3)

A key element of this recovery strategy is focus of actions on watersheds that can support viable populations and contribute to meeting Diversity Group requirements for distribution and redundancy. To assess their potential to contribute to species recovery, watersheds in the four Diversity Groups that supported historic populations of any of the three listed species have been placed into three categories, based on their potential to support populations with low risk of extinction. The three categories are Core 1, Core 2, and Core 3. Watersheds that supported the three species, historic and current distribution, and watershed classifications are presented in Tables 3-1, 3-2 and 3-3.

Core 1 watersheds possess the known ability or potential to support a viable population. For a population to be considered viable, it must meet the criteria for low extinction risk for Central Valley salmonids (Lindley *et al.* 2007). The criteria include population size, population decline, catastrophic decline and hatchery influence (see Table 4-1). Only a few of the Core 1 populations meet the long-term objective of low extinction risk; the remaining Core 1 populations have the potential to do so.

Core 2 populations meet, or have the potential to meet, the biological recovery standard for moderate risk of extinction set out in Table 4-1. These watersheds have lower potential to support viable populations, due to lower abundance, or amount and quality of habitat. These populations provide increased life history diversity to the ESU/DPS and are likely to provide a buffering effect against local catastrophic occurrences that could affect other nearby populations, especially in geographic areas where the number of Core 1 populations is lowest.

Core 3 watersheds have populations that are present on an intermittent basis and require straying from other nearby populations for their existence. These populations likely do not have the potential to meet the abundance criteria for moderate risk of extinction. Core 3 watersheds are important because, like Core 2 watersheds, they support populations that provide increased life history diversity to the ESU/DPS and are likely to buffer against local catastrophic occurrences that could affect other nearby populations. 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.

Table 3-1. Population presence, risk of extinction and classification of watersheds with historic populations of winter-run Chinook salmon. Currently there is one population in the mainstem Sacramento River downstream of Keswick Dam. “Primary”: top priority for reintroduction; “Candidate”: possible area for reintroduction; “Non-candidate”: reintroduction should not be attempted here. “NA”: not applicable.

Diversity Group	River, Creek or sub-reach	Historic Population	Current Population	Population Extinction Risk (from Williams *et al*. 2011)	Classification
Basalt and Porous Lava	Battle Creek	Yes	No	NA	Primary
	Mainstem Sacramento River (below Keswick)	No	Yes	moderate	Core 1
	McCloud River	Yes	No	NA	Primary
	Pit River	Yes	No	NA	Non-Candidate
	Little Sacramento River	Yes	No	NA	Candidate

Table 3-2: Population presence, risk of extinction, and classification of watersheds with historic and current populations of spring-run Chinook salmon. "Primary": top priority for reintroduction; "Candidate": possible area for reintroduction; "Non-candidate": reintroduction should not be attempted here. "NA": not applicable

Diversity Group	River, Creek or Sub-reach	Historic Population	Current Population	Population Extinction Risk (from Williams *et al.* 2011)	Classification
Basalt and Porous Lava	Battle Creek	Yes	Yes	Moderate	Core 1
	Mainstem Sacramento River (blw Keswick)	No	Yes	High	Core 2
	Little Sacramento River	Yes	No	NA	Candidate
	McCloud River	Yes	No	NA	Primary
	Pit River	Yes	No	NA	Non-Candidate
Northwestern California	Stony Creek	Yes	No	NA	Core 3
	Thomes Creek	Yes	Yes	NA	Core 3
	Cottonwood/Beegum	Yes	Yes	High	Core 2
	Clear Creek	Yes	Yes	Moderate	Core 1
Northern Sierra Nevada	Mokelumne (below Comanche)	No	No	NA	Candidate
	Mokelumne (above Pardee)	Yes	No	NA	Candidate
	American River (above Folsom)	Yes	No	NA	Candidate
	American River (below Nimbus)	Yes	No	NA	Non-Candidate
	Feather River (below Oroville)	No	Yes	High	Core 2
	West Branch Feather (above Oroville)	Yes	No	NA	Non-Candidate
	North Fork Feather (above Oroville)	Yes	No	NA	Candidate
	Middle Fork Feather (above Oroville)	Yes	No	NA	Non-Candidate
	South Fork Feather (above Oroville)	Yes	No	NA	Non-Candidate
	Yuba River (below Englebright)	No	Yes	High	Core 2
	North Yuba River (above Englebright)	Yes	No	NA	Primary
	Middle Yuba River (above Englebright)	Yes	No	NA	Primary
	South Yuba River (above Englebright)	Yes	No	NA	Candidate
	Butte Creek	Yes	Yes	Low	Core 1
	Big Chico	Yes	Yes	High	Core 2
	Deer Creek	Yes	Yes	High	Core 1
	Mill Creek	Yes	Yes	High	Core 1
	Antelope Creek	Yes	Yes	High	Core 2
Southern Sierra Nevada	Stanislaus River (below Goodwin)	No	No	NA	Candidate
	Upper Stanislaus River (abv New Melones)	Yes	No	NA	Candidate
	Tuolumne River (below La Grange)	No	No	NA	Candidate
	Upper Tuolumne River (abv La Grange and Don Pedro)	Yes	No	NA	Candidate
	Merced River (below Crocker Huffman)	No	No	NA	Candidate
	Upper Merced River (abv New Exchequer)	Yes	No	NA	Candidate
	San Joaquin River (below Friant)	No	No	NA	Primary
	San Joaquin above Friant	Yes	No	NA	Candidate

Table 3-3. Population presence, risk of extinction, and classification of watersheds with historic and current populations of steelhead. "Primary": top priority for reintroduction; "Candidate": possible area for reintroduction; "Non-candidate": reintroduction should not be attempted here. "NA": not applicable

Diversity Group	River, Creek or Sub-reach	Historic Population	Current Population	Population Extinction Risk (from Williams *et al*. 2011, Lindley *et al*. 2007)	Classification
Basalt and Porous Lava	Battle Creek	Yes	Yes	High	Core 1
	Cow Creek	Yes	Yes	Uncertain	Core 2
	Mainstem Sacramento River (below Keswick)	No	Yes	Uncertain	Core 2
	Little Sacramento River	Yes	No	NA	Candidate
	McCloud River	Yes	No	NA	Primary
	Pit River	Yes	No	NA	Non-Candidate
	Redding Area Tributaries	Yes	Yes	Uncertain	Core 2
Northwestern California	Putah Creek	Yes	Yes	Uncertain	Core 2
	Stony Creek	Yes	Yes	Uncertain	Core 3
	Thomes Creek	Yes	Yes	Uncertain	Core 2
	Cottonwood/Beegum	Yes	Yes	Uncertain	Core 2
	Clear Creek	Yes	Yes	Uncertain	Core 1
Northern Sierra Nevada	Cosumnes River	Yes	Yes	Uncertain	Core 3
	Mokelumne River (below Comanche)	No	Yes	High	Core 2
	Mokelumne River (above Pardee)	Yes	No	NA	Candidate
	American River (below Nimbus)	No	Yes	High	Core 2
	Upper American (above Folsom)	Yes	No	NA	Candidate
	Auburn Ravine	No	Yes	Uncertain	Core 2
	Dry Creek	Yes	Yes	Uncertain	Core 3
	Feather River (below Oroville)	No	Yes	High	Core 2
	West Branch Feather (above Oroville)	Yes	No	NA	Non-Candidate
	North Fork Feather (above Oroville)	Yes	No	NA	Candidate
	Middle Fork Feather (above Oroville)	Yes	No	NA	Non-Candidate
	South Fork Feather (above Oroville)	Yes	No	NA	Non-Candidate
	Bear River	Yes	Yes	Uncertain	Core 3
	Yuba River (below Englebright)	No	Yes	Uncertain	Core 2
	North, Middle, South Yuba Rivers (above Englebright)	Yes	No	NA	Primary
	Butte Creek	Yes	Yes	Uncertain	Core 2
	Big Chico	Yes	Yes	Uncertain	Core 2
	Deer Creek	Yes	Yes	Uncertain	Core 1
	Mill Creek	Yes	Yes	Uncertain	Core 1
	Antelope Creek	Yes	Yes	Uncertain	Core 1
Southern Sierra Nevada	Calaveras River (below New Hogan)	No	Yes	Uncertain	Core 1
	Upper Calaveras River (above New Hogan)	Yes	No	NA	Non-Candidate
	Stanislaus River (below Goodwin)	No	Yes	Uncertain	Core 2
	Upper Stanislaus River (above New Melones)	Yes	No	NA	Candidate
	Tuolumne River (below La Grange)	No	Yes	Uncertain	Core 2
	Upper Tuolumne River (abv La Grange and Don Pedro)	Yes	No	NA	Candidate
	Merced River (below Crocker Huffman)	No	Yes	Uncertain	Core 2
	Upper Merced River (above New Exchequer)	Yes	No	NA	Candidate
	San Joaquin River (below Friant)	No	No	NA	Candidate
	Upper San Joaquin (above Friant)	Yes	No	NA	Non-Candidate

Factoring Climate Change into Watershed Classifications

Areas targeted for emphasis in the strategy were selected based on current population distribution and abundance, existing habitat, and the impacts of existing stressors. Obviously, conditions are not static. The best available projections indicate that the climate is likely to warm considerably in the future. Lindley *et al.* (2007) reported on three greenhouse gas emission scenarios. The scenario with lowest emissions projected a mean summer air temperature increase of at least 2°C (3.6°F) in the geographical area under consideration, the intermediate scenario predicts an increase of around 5°C (9°F), and the highest emissions scenario, which is the least-likely, but still possible, projects an increase of 8°C (14.4°F) by the year 2100. Because spring-run Chinook salmon and steelhead both exhibit juvenile over-summer rearing as part of their life history strategies, long-term climate change considerations are discouraging for both species, unless coldwater refugia at local and larger scales exist or can be provided (see Section 6.6.2).

To generalize, populations in low elevation habitats are more likely to be negatively affected by temperature increases. Vulnerability to adverse climate change effects is assumed to be buffered somewhat in higher elevations (less change in snowmelt and water temperature) and in geology that results in springs and groundwater. Specifically, hydrologic changes are likely to be buffered somewhat in the Basalt and Porous Lava and Southern Sierra Nevada Diversity Groups due to groundwater dominance and elevations high enough to retain snow, respectively. One additional factor is habitat located below reservoirs; the assumption is that releases of cold water could be made in support of listed species, and serve as a buffer.

By screening Core 1 and "primary" watersheds for these characteristics, a very rough assessment of vulnerability of habitats to climate change was done to help identify watershed priorities. Watersheds at the lower elevations, which do not have coldwater springs or other sources of coldwater (e.g., Thomes Creek, Big Chico Creek), were among the lower priority watersheds. By contrast, watersheds where salmon have access to coldwater via high elevation, springs, or releases from storage reservoirs were considered higher priority.

3.3 Primary Objectives of the Recovery Effort

Based on recommendations from the Central Valley TRT, this recovery effort has two primary objectives: (1) secure existing populations by addressing stressors; and (2) reintroduce populations into historically occupied or other suitable areas (Lindley *et al.* 2007). These objectives are considered equal in importance and both should be pursued simultaneously. Each objective is more fully described below.

3.3.1 Secure Existing Populations

All four historic winter-run Chinook salmon populations are extinct, with only one current population that is supplemented with hatchery production. Of the 18 or 19 populations of spring-run Chinook salmon, three remain. One (Butte Creek) has low risk of extinction; the other two (Deer Creek and Mill Creek) are at high risk of extinction. Of perhaps 81 historic steelhead populations, fewer than two dozen remain. These numbers reflect the perilous condition of these species, and underline the importance of the few remaining populations to the long term recovery of the species. From this current, limited pool must come the individuals and genetic composition to support broader future population distribution. Loss of any of these populations would further jeopardize chances for recovery.

The strategy is consistent with the TRT recommendation that every extant population be viewed as necessary for the recovery of the ESUs and DPS. Wherever possible, the status of extant populations should be improved. Further information on population status and watershed condition can be found in Appendix A- Watershed Profiles.

Protection and enhancement of habitat for existing Core 1 and Core 2 populations are both vitally important. The strategy emphasizes protections and improvements in watersheds that support these populations, as well as actions necessary to eliminate or reduce threats present in the rivers and bay delta that connect them with the ocean.

Actions that protect and improve populations in Core 1 and Core 2 watersheds are the highest priority for investment of limited resources. This does not mean actions should not be taken in watersheds that support Core 3 populations, and, in fact, local groups are encouraged to undertake appropriate actions. It simply means that agencies should not substitute action in Core 3 watersheds for efforts in the Core 1 and Core 2 watersheds.

Address Threats

The primary means of securing existing populations is to reduce or eliminate the threats to the species and their habitats. Therefore, it was necessary to first identify the threats to each of the three species covered in this recovery plan; this was accomplished with the threats assessment described in Appendix B. Next, specific actions that address each prioritized threat must be identified. Those threat abatement actions (i.e., recovery actions), and the steps taken to identify and prioritize them, are described in Chapter 5.

3.3.2 Reintroduce Populations in Historically Occupied or Suitable Habitat

Meeting objectives for redundancy and distribution will require reintroducing some populations to habitats that historically supported the species, but are currently inaccessible because of existing dams (e.g. McCloud River). Also necessary are reintroduction of fish into watersheds that are currently accessible, but not utilized (e.g., winter-run Chinook salmon in Battle Creek).

Efforts to reintroduce fish will be challenging and expensive, and will require tremendous effort. To focus efforts, the strategy sets priorities for redundancy and spatial distribution within the four diversity groups. Priorities, based on existing information for the three listed species, are shown in **Tables 3-4, 3-5, and 3-6**. The highest-priority watersheds (primary watersheds) for re-introduction have been identified based on the current understanding of habitat conditions and the fact that reintroduction planning efforts are already underway in those watersheds. Watersheds with less potential, or where potential has not been assessed are classified as “candidates.”

This classification is based on current information. As the availability of habitat in these areas is further assessed, and measures necessary to facilitate the re-introductions evaluated and compared, priorities may change.

Populations will need to be re-established in some areas now blocked by dams or that have insufficient flows. Assuming that most of these dams will remain in place for the foreseeable future, it will be necessary to provide fish passage around the dams in both directions. Near-term priority actions will include assessing habitat suitability and passage logistics. In the long-term reintroductions to high elevation habitats will need to be successful in at least a few watersheds, particularly as air temperatures increase and precipitation patterns change (see Chapter 6). Moving forward, information is needed to confirm that conditions are suitable for reintroduction in the priority watersheds, to determine which candidate watersheds have the highest likelihood of successful reintroduction, and to determine what measures are necessary to facilitate reintroductions.

A complete picture of the watershed priorities for each species are displayed in **Figures 3-4, 3-5, and 3-6**. These maps also provide a picture of what the distribution of a recovered ESUs/DPS would look like.

Table 3-4. Priorities for Winter-Run Chinook Salmon by Diversity Group.

Diversity Group	Current Core 1 Population	Diversity Group Objective*	Re-introduction Priorities	Current Core 2 Populations
Basalt and Porous Lava	Sacramento River	3	McCloud River (Primary)	None
			Battle Creek (Primary)	

*number of populations with low risk of extinction

Table 3-5. Priorities for Spring-Run Chinook Salmon by Diversity Group.

Diversity Group	Current Core 1 Populations	Diversity Group Objective*	Re-introduction Priorities	Current Core 2 Populations
Basalt and Porous Lava	Battle Creek	2	McCloud River (Primary)	Sacramento River (below Keswick)
Northwestern California	Clear Creek	1	None	Cottonwood/Beegum
Northern Sierra Nevada	Mill Creek	4	Yuba River above Englebright (Primary)	Yuba River (below Englebright)
	Deer Creek			Antelope Creek
	Butte Creek			Feather River (below Oroville)
Southern Sierra Nevada	None	2	San Joaquin (below Friant) (Primary)	None Currently Identified
			One Candidate Watershed	

* number of populations with low risk of extinction

Table 3-6. Priorities for Steelhead by Diversity Group.

Diversity Group	Current Core 1 Populations	Diversity Group Objective	Re-introduction Priorities	Current Core 2 Populations
Basalt and Porous Lava	Battle Creek	2	McCloud River (Primary)	Cow Creek
				Redding Area Tributaries
				Sacramento River (below Keswick)
Northwestern California	Clear Creek	1	None	Thomes Creek
				Putah Creek
				Cottonwood/Beegum
Northern Sierra Nevada	Antelope Creek	4	Yuba River above Englebright (Primary)	Yuba River (below Englebright Dam)
	Deer Creek			Butte Creek
				Feather River (below Oroville Dam)
	Mill Creek			Big Chico Creek
				Auburn Ravine
				American River
Southern Sierra Nevada	Calaveras River	2	One Candidate Watershed	Stanislaus River (below Goodwin)
				Merced River (below Crocker Huffman)
				Tuolumne River (below La Grange)
* number of populations with low risk of extinction				

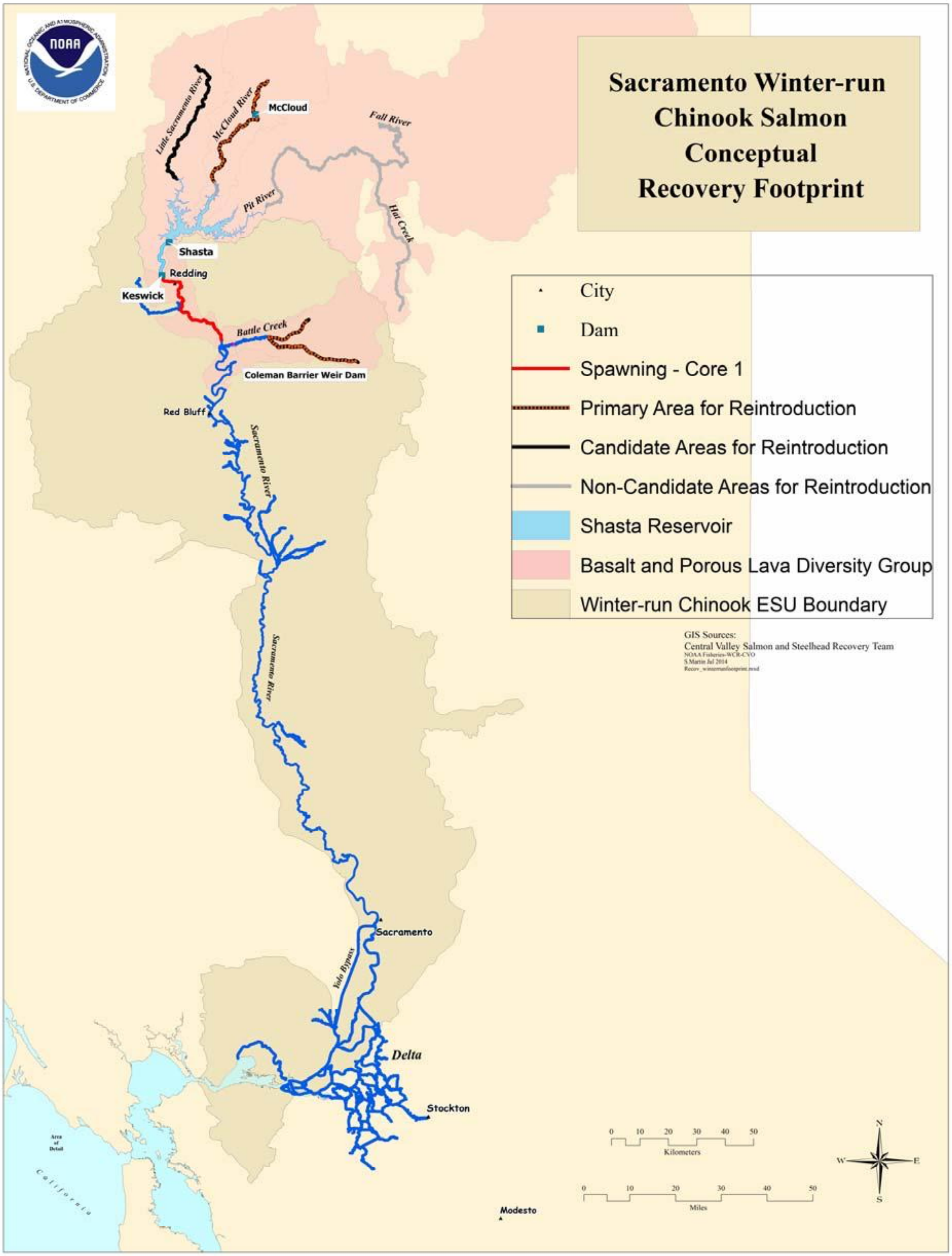
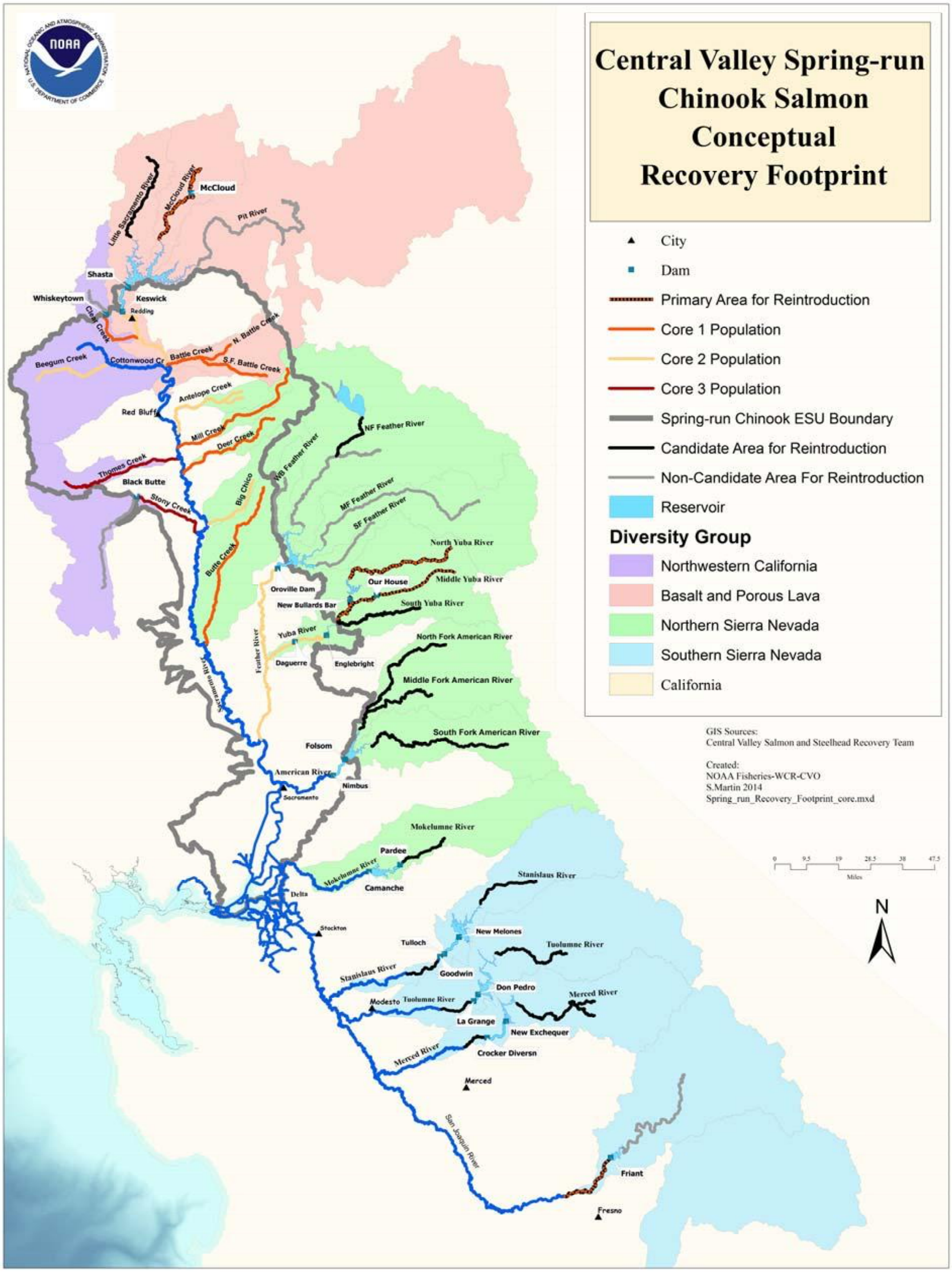


Figure 3-4. Sacramento River Winter-run Chinook Salmon Recovery Footprint. The primary and candidate areas for reintroduction depicted on this map are areas where, although dams block access, the primary constituent elements that are necessary to support freshwater migration, holding, spawning and rearing still exist or could be restored.



GIS Sources:
Central Valley Salmon and Steelhead Recovery Team

Created:
NOAA Fisheries-WCR-CVO
S.Martin 2014
Spring_run_Recovery_Footprint_core.mxd

Figure 3-5. Central Valley Spring-run Chinook Salmon Recovery Footprint. The primary and candidate areas for reintroduction depicted on this map are areas where, although dams block access, the primary constituent elements that are necessary to support freshwater migration, holding, spawning and rearing still exist or could be restored.

Figure 3-6. California Central Valley Steelhead DPS Recovery Footprint. The primary and candidate areas for reintroduction depicted on this map are areas where, although dams block access, the primary constituent elements that are necessary to support freshwater migration, holding, spawning and rearing still exist or could be restored.

Re-introduction of anadromous fishes to historic habitats will require a new approach to watershed management, especially in regard to the operation and licensing of hydroelectric projects. Many of the keystone passage impediments to upstream habitat are regulated by the Federal Energy Regulatory Commission (FERC). In many watersheds, FERC also regulates upstream hydroelectric projects and facilities, and in most cases the licenses issued by FERC expire on different schedules, making the necessary, coordinated ecosystem-wide approach to relicensing difficult. Numerous hydroelectric licenses will come up for renewal in the next 20 years. Re-introduction of fish to historic habitats will require concerted watershed-scale approaches by FERC and other involved parties to align license schedules, develop new stream flow regimes, and facilitate comprehensive fish passage plans. This approach is especially necessary in the McCloud, upper Yuba, upper American, and other watersheds where hydroelectric projects influence areas identified for re-introduction, and affect downstream habitats that are essential for recovery. Re-introduction will require improved resource agency coordination, including joint filings under FERC proceedings, aligning regulatory schedules and products, and sharing biological, technical, and policy expertise on high priority projects.

The Sacramento River winter-run Chinook salmon ESU currently has one population, and that population spawns outside the species historic spawning range. For that reason, introductions into historically occupied habitat are necessary to meet requirements for redundancy. Re-introduction in the McCloud Rivers has the highest probability of success. Priority for the third population in the Diversity Group is introduction of the species in Battle Creek, which has suitable habitat for the species.

As with winter-run Chinook salmon, spring-run Chinook salmon will require re-introductions into historically occupied or currently suitable habitat in the Basalt and Porous Lava, Northern Sierra Nevada, and Southern Sierra Nevada Diversity Groups, in order to meet requirements for distribution and redundancy. Primary areas for spring-run Chinook salmon re-introduction into historic habitat include upstream of Shasta Dam in the Basalt diversity group and the Yuba River above Englebright Dam in the Northern Sierra Nevada. In the Southern Sierra Nevada, the strategy calls for reintroduction of spring-run Chinook salmon in the San Joaquin River below Friant Dam, and in one additional watershed in the Southern Sierra Nevada (Table 3-5).

Reintroductions of steelhead to historically occupied or currently suitable habitat will be necessary to meet objectives for distribution and redundancy in the Basalt and Porous Lava, Northern Sierra Nevada, and Southern Sierra Nevada Diversity Groups. Priorities for re-introduction are included in Table 3-6. These priorities include the McCloud River in the Basalt and Porous Lava Group and the Yuba River above Englebright in the Northern Sierra Nevada. Top priority areas for steelhead reintroductions in the Southern Sierra Nevada have yet to be established.

Reintroducing Chinook salmon and steelhead to historic habitats, particularly those habitats upstream of impassable barriers, will be extremely complicated and many questions will need to be answered as the projects progress. A few of the most important biological questions include:

- which donor populations should be used?;

- how will donor fish be collected, how many will be needed, and what life stages should be used?;
- how and where will juveniles produced upstream of a barrier be collected, and how will they be transported downstream of the barrier?; and
- where and when will adults and juveniles be released?

In addition to those questions, which apply to all three species, re-introducing steelhead upstream of impassable barriers comes with unique complications and associated questions. First, because steelhead are iteroparous (i.e., they spawn multiple times in their lifetime), the question of what to do with the adult steelhead that spawn upstream of the barrier arises. Assuming those adults should be allowed to carry out their natural life history strategy by returning to the ocean after spawning, an effective collection method will need to be implemented.

Another important issue related to steelhead re-introductions deals with the occurrence of resident *O.mykiss* upstream of the barriers, which, in some Central Valley locations, contain genetic material representative of ancestral *O.mykiss* (Garza and Pearse 2008). This adds additional considerations to the donor stock selection question raised above – should the ancestral stock be used or a below barrier stock? This question and others associated with integrating below and above barrier populations will need to be addressed.

Lastly, reintegrating *O.mykiss* below and above barriers does not guarantee an increase in steelhead abundance, at least in the short-term while the selection regime favors residency. There are more resident *O.mykiss* than anadromous *O.mykiss* in the Central Valley (McEwan 2001), indicating selection pressure in the favor of the resident form. If selection pressures on the anadromous and resident form were equal, then one would expect their relative abundances to be somewhat equal and likely biased to anadromous *O.mykiss* because anadromous fish attain a much larger size than resident fish, and thus are able to outcompete the resident fish for quality spawning habitat and are much more fecund, producing twice as many eggs per body weight (Moyle 2002). Hypotheses for why there are more resident than anadromous *O.mykiss* in the Central Valley include: (1) low survival of *O.mykiss* through the Delta; (2) cold water releases from dams providing thermally survivable habitat for *O.mykiss* to live in year-round; and (3) a combination of 1 and 2. Achieving a better understanding of the factors influencing the selection between anadromous and resident life history strategies is an important step for efforts to expand steelhead habitat upstream of impassable barriers.

In the face of all of the complications and questions related to anadromous salmonid reintroductions in the Central Valley, it is important to recognize that recovering winter-run Chinook salmon, spring-run Chinook salmon, and steelhead is highly unlikely without significant habitat expansion (Lindley *et al.* 2007; Cummins *et al.* 2008; Moyle *et al.* 2008).

Role of Hatcheries in Securing Existing Populations and Reintroducing Populations in Historically Occupied or Suitable Habitat

The principal strategy of salmonid conservation and recovery continues to be through the protection and restoration of the healthy ecosystems upon which they depend, in line with the ESA's stated purpose to conserve "the ecosystems upon which endangered and threatened species depend" (ESA section 2(b)). However, a natural recovery of local extinctions depends on one or more recolonization events, a process that operates on an indefinite timescale. Likewise, the viability of a depressed population, characterized by small size, fragmented structure, and impacted genetics (e.g., bottlenecks, inbreeding, outbreeding depression, etc.), may be so compromised that its response to restored or increased availability of habitat is not sufficient to prevent imminent extinction. Either case may demand management intervention to attain viable salmonid populations. Conservation hatcheries may provide an appropriate means for establishing new populations and for allowing existing populations to recover. Two relevant examples from the Central Valley are the development of a conservation hatchery to help re-establish spring-run Chinook salmon in the San Joaquin River and the ongoing operation of the winter-run Chinook salmon conservation program at the Livingston Stone National Fish Hatchery.

There is considerable uncertainty regarding the ability of artificial propagation to increase population viability over the long-term, and it cannot be assumed that artificial augmentation will reduce extinction risk. There is a risk to natural recovery from increasing dependency on hatchery production. Conservation hatcheries must therefore monitor the effects of their programs on the natural population using criteria which would trigger modification to or cessation of the conservation program.

3.4 ADAPTIVE MANAGEMENT AND MONITORING

Successful adaptive management relies on accurate data provided by effective long-term monitoring programs. Past and current CV salmonid monitoring programs have suffered from inconsistent and/or inadequate funding. For successful species recovery and effective use of limited resources, a funding mechanism for long term effective monitoring of CV salmonids should be a fundamental top priority in the recovery plan.

Implementation of the Recovery Strategy will involve actions throughout the ESUs and DPS, conducted by a variety of agencies and stakeholders, addressing a multitude of site specific and systematic issues. These efforts are complicated by uncertainties, which include the actual abundance and distribution of the listed species, interactions between the species and their habitat, and the design and effectiveness of recovery actions. An effective means of gathering and sharing information on the condition of the resources, and the lessons learned during implementation of actions, is essential to bring accountability and efficiency to the process, and to allow for informed revisions to the recovery approach.

Adaptive management and monitoring will provide a framework to obtain the appropriate types and amounts of data to evaluate the effectiveness of recovery actions and progress toward recovery. The plan, outlined below, includes an approach to coordination of the numerous monitoring and research tasks required for implementation of the strategy.

Track Performance

This effort will document that recovery actions are implemented, as well as determine if they were implemented as intended and designed.

Monitor effectiveness of implemented actions

The goal of this component of the plan is to determine if actions, once implemented, meet their objectives. Because priority for future restoration efforts will be given to actions shown to be effective, this information will lead to adjustments in priority for actions. At the site level, it will assist in project design, to take advantage of lessons learned.

Review progress in meeting recovery criteria

This information is needed to assess progress toward the goal of delisting, and includes three parts: viability in each Diversity Group (population distribution and abundance), habitat monitoring, and evaluation of threats.

Viability

Existing adult salmonid escapement monitoring programs in the Central Valley are currently inadequate to estimate population status and evaluate population trends in a statistically valid manner for the following management purposes: (1) providing a sound basis for assessing recovery of listed stocks; (2) monitoring the success of restoration programs; (3) evaluating the contribution of hatchery fish to Central Valley populations; and (4) managing sustainable ocean and inland harvest (Allen 2005).

Numerous programs are underway to collect information on anadromous fish species in the Central Valley. Although each of these programs and monitoring activities provides important information about the overall status of the specific resources and their habitats in the Central Valley and Bay/Delta, they are generally implemented on a project-by-project basis. Other streams and associated populations within the Chinook salmon ESUs and the steelhead DPS within the Central Valley Domain have no existing monitoring surveys or programs. Clearly, a more coordinated and comprehensive system-wide watershed and population monitoring system is needed.

As previously noted, there is great need for the development and implementation of a comprehensive monitoring plan for steelhead populations throughout the Central Valley Domain. The Central Valley Domain TRT was unable to assess the status of the California Central Valley steelhead DPS because nearly all of its approximately 80 historic populations are classified as data-deficient, with a few exceptions that are closely associated with a hatchery (Lindley *et al.* 2007).

In addition to population status and trend evaluation, accurate estimation of adult Chinook salmon and steelhead spawner escapement is necessary for harvest management. Age and run-specific escapement data in the Central Valley are necessary to utilize more accurate models associated with ocean harvest management.

Habitat

Watershed-level monitoring, including selected habitat variables, is necessary to evaluate the effectiveness of multiple restoration actions. Watershed-specific monitoring evaluations will contribute to the assessment of threat abatement and population responses. Additionally, the long-term effects of habitat restoration actions need to be assessed throughout the Central Valley Domain. Components that require monitoring include long-term changes in the characteristics of targeted recovery/restoration components such as aquatic habitat, riverine channel configuration, riparian vegetation, and floodplain structure and function.

Long-term habitat monitoring will also include parameters useful in tracking trends of climate change effects, such that necessary modifications to recovery objectives can be made.

Evaluation of Threats

Actions included in the strategy are intended to address threats to the listed species and their habitats. Monitoring implementation and effectiveness of actions will help track progress and provide information necessary to guide adaptive management. This data, along with monitoring of watershed and habitat conditions outlined above, will provide the information necessary to evaluate the degree to which threats have been eliminated or reduced as well as to identify any new threats.

Coordination research and monitoring targeted to address information gaps

Recovering the Chinook salmon ESUs and steelhead DPS will require numerous investigations and studies. The majority of these will address a specific question (e.g., gravel movement) at a particular site, while some are fairly broad questions (e.g., assess reintroduction potential above a group of impoundments). Also necessary are the system wide habitat and population monitoring programs outlined above. Coordination of these efforts is necessary so that questions are addressed in a priority sequence, and so that information and approaches are shared and efforts are not duplicated. A consistent framework for research and monitoring will directly inform recovery objectives and goals.

Reporting

There is a need to effectively share information with the public, stakeholders, and cooperators. To this end, NOAA is in the process of developing an internet-based recovery action tracking system. The reporting will support the annual reporting for the Government Performance and Results Act, Bi-Annual Recovery Reports to Congress, and the 5-Year Status Review.

4.0 Recovery Goals, Objectives and Criteria

> *"Merely increasing a species' numbers, range and abundance does not ensure its long-term health and sustainability; only by alleviating threats can lasting recovery be achieved."*
>
> \- Interim Endangered and Threatened Species Recovery Planning Guidance (NMFS 2010b)

This chapter describes the goals of this Recovery Plan and includes a brief discussion of the biological basis for meeting those goals for Sacramento River winter-run Chinook salmon, Central Valley spring-run Chinook salmon, and Central Valley steelhead. This chapter also explains the objectives and criteria to be used to determine when recovery of the listed species has been achieved. Two main types of criteria are presented. First, biological criteria pertaining to both ESU/DPS and population viability are described. Next, threat abatement criteria are covered to determine when the threats that led to listing of the species have been eliminated or adequately reduced.

4.1 Recovery Goals

The overarching goal of this Recovery Plan is the removal of the Sacramento River winter-run Chinook salmon ESU, Central Valley spring-run Chinook salmon ESU, and California Central Valley steelhead DPS from the Federal List of Endangered and Threatened Wildlife (50 CFR 17.11; 50 CFR 224.101; 50 CFR 223.102). Because recovery plans are not regulatory documents, successful implementation and recovery of listed species will require the support, efforts and resources of many entities, from Federal and State agencies to individual members of the public. Another goal will be to encourage and support effective partnerships with regional stakeholders to meet the objectives and criteria of the Recovery Plan. The objectives and criteria to accomplish the overarching goal of species delisting build upon the technical input and guidance provided by the Central Valley TRT, and other information provided during public workshops and co-manager reviews. Much of the technical recovery discussion in this section is taken directly from information developed by the TRT (Lindley *et al.* 2004; 2006; 2007).

The Endangered and Threatened Species Recovery Planning Guidance (NMFS 2010b) describes the recovery planning goal as recovery and long-term sustainability of an endangered or threatened species and, therefore, delisting of the species. Further, NMFS (2010b) states that goals usually can be subdivided into discrete component objectives which, collectively, describe the conditions (criteria) necessary for achieving the goal. Simply stated, recovery objectives are the parameters of the goal, and criteria are the values for those parameters. The objectives and related criteria, representing the components of the recovery goal, identify mechanisms for pursuing the goal (including necessary recovery actions) and allow confirmation when the goal has been reached.

According to NMFS (2010b), recovery and long-term sustainability of an endangered or threatened species require:

- ☐ Adequate reproduction for replacement of losses due to natural mortality factors (including disease and stochastic events)
- ☐ Sufficient genetic robustness to avoid inbreeding depression and allow adaptation
- ☐ Sufficient habitat (type, amount, and quality) for long-term population maintenance
- ☐ Elimination or control of threats (this may also include having adequate regulatory mechanisms in place).

4.2 Integrating TRT Products into Recovery Objectives and Criteria

The ESA requires that recovery plans, to the maximum extent practicable, incorporate objective, measurable criteria which, when met, would result in a determination in accordance with the provisions of the ESA that the species be removed from the Federal List of Endangered and Threatened Wildlife; the criteria described herein fulfill that role with regard to the aforementioned species.

Population or demographic parameters are considered through the biological recovery criteria, while the threats criteria consider threats under the five ESA listing factors in ESA section 4(a)(1) (threats criteria). Together, these make up the "objective, measurable criteria" required under section 4(f)(1)(B).

These recovery criteria were derived from the TRT products (Appendix C), and as such, they represent the best scientific analysis incorporating the most current understanding of the ESUs and DPS and their populations.

4.2.1 Biological Basis for Recovery Criteria

For delisting, the ESU/DPS should meet the criteria for populations and diversity groups listed below in Sections 4.3.2 and 4.3.4. Downlisting (endangered to threatened) criteria for winter-run Chinook salmon are provided in Section 4.3.4.1. These delisting and downlisting criteria are based on population- and ESU-level considerations as discussed below in Sections 4.2.1.1 and 4.2.1.2.

Population Level Considerations

This plan includes both population-level and Diversity Group recovery criteria. The population-level criteria are used to determine whether a population is viable or not. A viable population is one with a low extinction risk in the wild over the long-term (McElhany *et al*. 2000).

The Central Valley TRT incorporated the four VSP parameters into assessments of population viability, and two sets of population viability criteria were developed, expressed in terms of extinction risk (Table 4-1). The first set of criteria deal with direct estimates of extinction risk from population viability analysis (PVA) models. If data are available and such analyses exist and are deemed reasonable for individual populations, such PVA assessments may be efficient for assessing extinction risk. The Central Valley TRT assumed that, for PVA results, a 5 percent or less risk of extinction in 100 years is an acceptably low extinction risk for populations (Lindley *et al.* 2007).

The second set of criteria are simpler and do not require PVA modeling results. These simpler extinction risk criteria are the basis of the population-level recovery criteria used in this Recovery Plan, with the low extinction risk levels defining what constitutes a viable population. The simpler criteria from Table 4-1 include population size (and effective population size), population decline, catastrophic rate and effect, and hatchery influence. Estimators for the various viability criteria are presented in Table 4-2.

Population Size (Abundance)

The effective population size criteria (second row of Table 4-1) relate to loss of genetic diversity. Very small populations, for example with $Ne < 50$, suffer severe inbreeding depression (Franklin 1980; Soulé 1980 *in* Lindley *et al.* 2007), and normally outbred populations with such low *Ne* have a high risk of extinction from this inbreeding. Somewhat larger, but still small, populations can be expected to lose variation in quantitative traits through genetic drift faster than it can be replaced by mutation. With future research, it may be possible to better define population size targets that conserve genetic variation and account for migration and genetic structuring within ESUs/DPS.

Census size N can be used if direct estimates of effective population size are not available. Census size is estimated as the product of the mean run size and the average generation time. The average spawning run size is computed as the mean of up to the three most recent generations, if that much data are available.

The general criteria for population size discussed below may be adjusted as further information is developed. Healthy populations should be at or near carrying capacity in most years. As such, a detailed and thorough assessment of each watershed's carrying capacity should be conducted, and the recovery criterion for abundance should be based on that estimated carrying capacity.

As recovery actions are implemented and habitats are restored and expanded, the low extinction risk abundance criterion (i.e., census size>2,500) may be too low for large watersheds or for abundant populations. For example, Butte Creek has supported spring-run Chinook salmon populations with a census size well in excess of 2,500 since 1998, suggesting that the carrying capacity of that system may be greater than that criterion.

Carrying capacity assessments could be accomplished by applying a consistent approach to measure habitat capacity throughout each ESU/DPS and then relating that capacity to assumed spawner density thresholds that correspond to varying levels of extinction risk (Williams *et al.* 2008). Until such population-specific abundance recovery criteria are developed, the low and moderate extinction risk abundance criterion (Table 4-1) serve as benchmarks for the developing population delisting criteria.

Population Decline (Productivity)

This criterion is intended to capture demographic risks. The rationale behind the population decline criteria are fairly straight forward: severe and prolonged declines to small run sizes are strong evidence that a population is at risk of extinction. Population growth (or decline) rate is estimated from the slope of the natural logarithm of spawners versus time for the most recent 10 years of spawner count data.

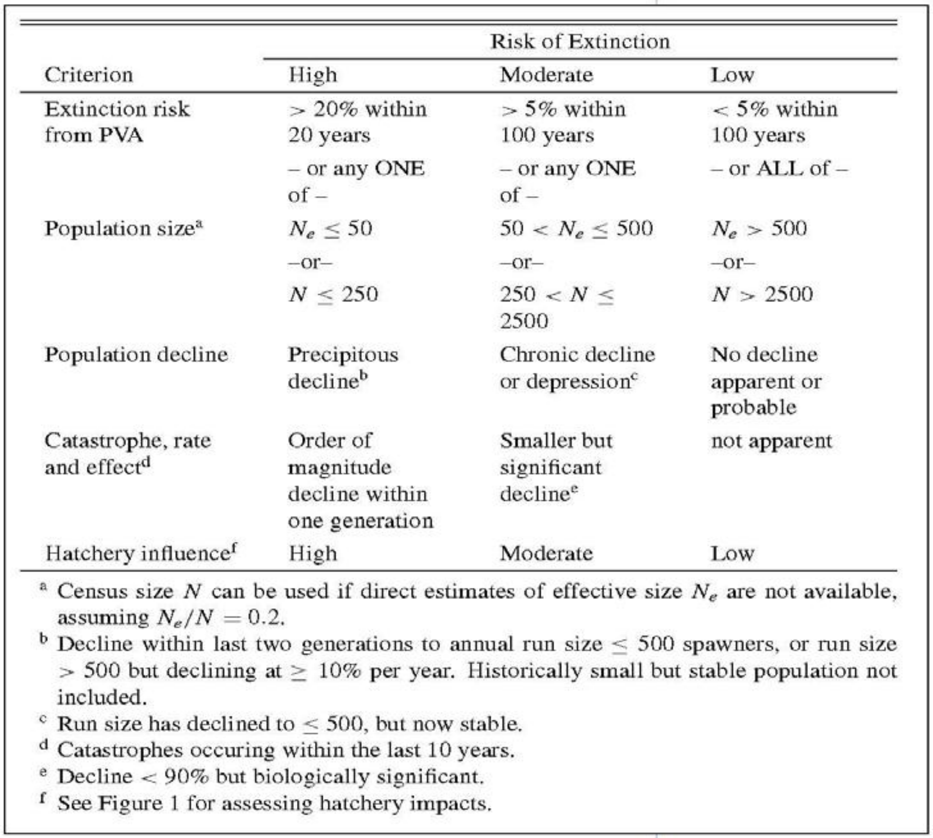
Catastrophic Rate and Effect (Productivity)

The overall goal of the catastrophe criterion is to capture a sudden shift from a low risk state to a higher risk state. Catastrophes are defined as instantaneous declines in population size due to events that occur randomly in time, in contrast to regular environmental variation. A high risk catastrophic event is one that causes a 90 percent decline in population size over one generation. A moderate risk catastrophic event is one that is smaller but biologically significant, such as a year-class failure.

Hatchery Influence (Diversity)

The spawning of hatchery fish in the wild is a potentially serious threat to the viability of natural populations. Population genetics theory predicts that hatchery fish can negatively impact wild populations when they spawn in the wild. In assessing the genetic impact of immigration on a population, considerations include the source of the immigrants, duration of the impact, the number of immigrants relative to the size of the recipient population, and how genetically divergent the immigrants are from the recipient population. Definitions of the manner in which different immigration scenarios relate to extinction risk for natural populations are summarized in Figure 4-1. Application of these definitions can result in a low-risk classification even with moderate amounts of straying from best-practices hatcheries, as long as other risk measures are acceptable (Lindley *et al.* 2007). The fraction of naturally-spawning hatchery origin fish is the mean fraction over one to four generations.

Table 4-1. Criteria for assessing the Level of Risk of Extinction for Populations of Pacific Salmonids, Applied to the Chinook Salmon ESUs and the Steelhead DPS in the Central Valley Domain (from Lindley et al. 2007).



	Risk of Extinction		
Criterion	High	Moderate	Low
Extinction risk from PVA	$> 20\%$ within 20 years – or any ONE of –	$> 5\%$ within 100 years – or any ONE of –	$< 5\%$ within 100 years – or ALL of –
Population size[a]	$N_e \leq 50$ –or– $N \leq 250$	$50 < N_e \leq 500$ –or– $250 < N \leq 2500$	$N_e > 500$ –or– $N > 2500$
Population decline	Precipitous decline[b]	Chronic decline or depression[c]	No decline apparent or probable
Catastrophe, rate and effect[d]	Order of magnitude decline within one generation	Smaller but significant decline[e]	not apparent
Hatchery influence[f]	High	Moderate	Low

[a] Census size N can be used if direct estimates of effective size N_e are not available, assuming $N_e/N = 0.2$.

[b] Decline within last two generations to annual run size $\leq$ 500 spawners, or run size $>$ 500 but declining at $\geq$ 10% per year. Historically small but stable population not included.

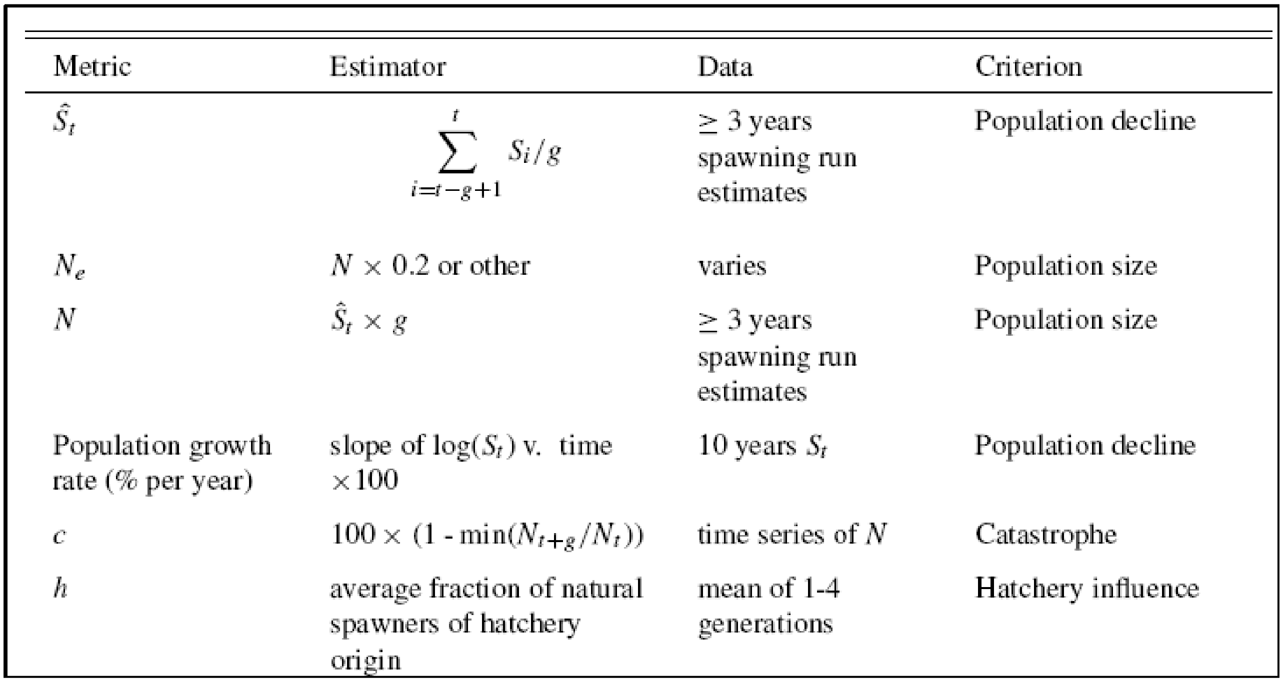
[c] Run size has declined to $\leq$ 500, but now stable.

[d] Catastrophes occuring within the last 10 years.

[e] Decline $<$ 90% but biologically significant.

[f] See Figure 1 for assessing hatchery impacts.

Table 4-2 Estimation Methods and Data Requirements for Population Metrics. S_t denotes the number of spawners in year t; g is mean generation time, assumed as three years for California salmon (from Lindley et al. 2007).



Metric	Estimator	Data	Criterion
$\hat{S}_t$	$\sum_{i=t-g+1}^{t} S_i/g$	$\geq$ 3 years spawning run estimates	Population decline
N_e	$N \times 0.2$ or other	varies	Population size
N	$\hat{S}_t \times g$	$\geq$ 3 years spawning run estimates	Population size
Population growth rate (% per year)	slope of $\log(S_t)$ v. time $\times 100$	10 years S_t	Population decline
c	$100 \times (1 - \min(N_{t+g}/N_t))$	time series of N	Catastrophe
h	average fraction of natural spawners of hatchery origin	mean of 1-4 generations	Hatchery influence

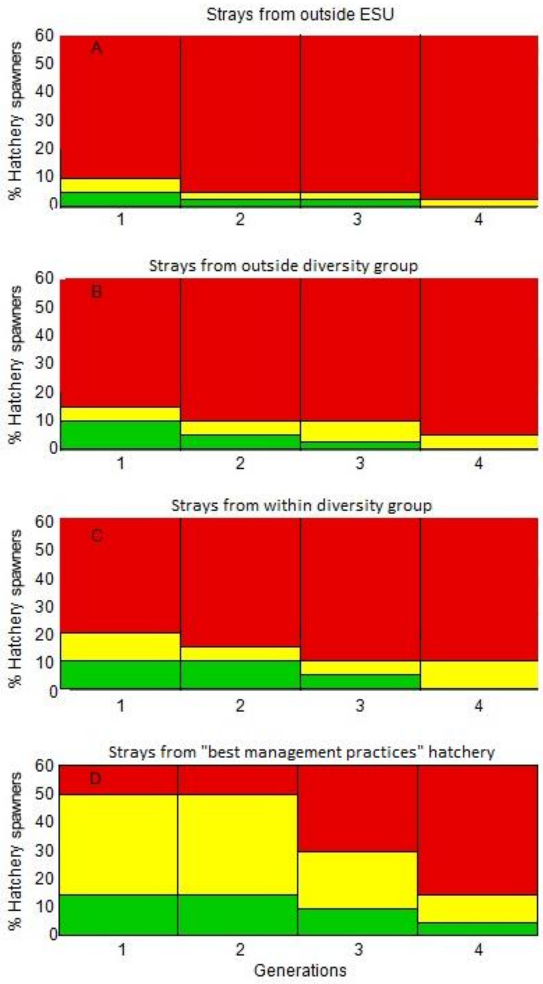


Figure 4-1. Extinction Risk Levels Corresponding to Different Amount, Duration and Source of Hatchery Strays.

Green bars indicate the range of low risk, yellow bars moderate risk, and red areas indicate high risk. Which chart to use depends on the relationship between the source and recipient populations. (A) hatchery strays are from a different ESU than the wild population. (B) Hatchery strays are from the same ESU but from a different diversity group within the ESU. (C) Hatchery strays are from the same ESU and diversity group, but the hatchery does not employ "best management practices." (D) Hatchery strays are from the same ESU and diversity group, and the hatchery employs "best management practices." (from Lindley *et al.* 2007)

Diversity Group and ESU/DPS Considerations

In order to delist the winter-run and spring-run Chinook salmon ESUs and the steelhead DPS, the TRT stated that there must be at least two viable populations in each diversity group (Lindley *et al.* 2007). This ESU/DPS-level recovery goal addresses the representation and redundancy rule for ESU/DPS viability.

The TRT recommendation of at least two viable populations is not applicable to the Northwestern California diversity group for spring-run Chinook salmon and steelhead, because this diversity group did not historically support viable populations. However due to management and restoration activities, the potential exists to support a viable population in Clear Creek.

As previously explained in Section 3.2.1, full steelhead recovery can be achieved without representation from either the Suisun Bay or Central Western California diversity groups.

4.3 Biological Objectives and Criteria at the Population, Diversity Group, and ESU/DPS Level

Implementation of the Recovery Plan is designed to ultimately achieve objectives for the ESUs/DPS at the Diversity Group level, and at the population level (i.e. watershed level) for the four VSP criteria of abundance, productivity, diversity, and spatial structure. Objectives addressing these requirements include demographic parameters, reduction or elimination of threats to the species (the listing factors), and any other particular vulnerability or biological needs inherent to the species.

4.3.1 Population Objectives

In general, viable populations should demonstrate a combination of population abundance, growth rate and genetic integrity that produces an acceptable probability of population persistence. Specifically, viable populations should meet the low extinction risk levels for the population decline and population size criteria described below in the following section.

4.3.2 Population Level Criteria

Consistent with the strategic approach to achieve recovery, this Recovery Plan establishes the following criteria for the viability of individual populations, similar to NMFS (2005b). The criteria are based on the VSP criteria for productivity and abundance, and diversity outlined in section 4.2.1

Low risk of extinction criteria

- ☐ Census population size is >2,500 adults -or- Effective population size is >500
- ☐ No productivity decline is apparent
- ☐ No catastrophic events occurring or apparent within the past 10 years
- ☐ Hatchery influence is low (see Figure 4-1).

Moderate risk of extinction criteria

- ☐ Census population size is 250 to 2,500 adults -or- Effective population size is 50 to 500 adults
- ☐ Productivity: Run size may have dropped below 500, but is stable
- ☐ No apparent decline in population growth rate resulting from catastrophic events within the past 10 years
- ☐ Hatchery influence is moderate

4.3.3 ESU/DPS Objectives

ESU/DPS viability depends on the number of populations within the ESU/DPS, their individual status, their spatial arrangement with respect to each other and sources of catastrophic disturbance, and the diversity of the populations and their habitats. In the most general terms, ESU/DPS viability increases with the number of populations (redundancy), the viability of these populations, spatial distribution of the populations, the diversity of the populations, and the diversity of habitats that they occupy.

For the ESUs and DPS to achieve recovery, each of the Diversity Groups should support both viable and dependent populations and meet goals for redundancy and distribution. Thus, an overall goal is to sustain populations in each of the Diversity Groups.

4.3.4 ESU/DPS Criteria

ESU Level Downlisting Criteria for Endangered Winter-run Chinook

Downlisting is the reclassification of a species from endangered to threatened. Two criteria have been identified with regard to downlisting of winter-run Chinook salmon from endangered to threatened:

- ☐ One population should meet each of the low extinction risk criteria described in section 4.3.2.; and
- ☐ In addition to the one viable population, the ESU should include one other spawning population that meets the moderate extinction risk criteria described in Table 4-1.

These winter-run Chinook salmon downlisting criteria were identified because, when achieved, the species' viability would be notably improved from its current status, but would still be far from recovered (i.e., delisted). Currently, there is one population of winter-run Chinook salmon. In order to achieve the downlisting criteria, the species would need to be composed of two populations – one viable and one at moderate extinction risk. Having a second population would improve the species' viability, particularly through increased spatial structure and abundance, but further improvement would be needed to reach the goal of recovery. As identified in the next section, to delist winter-run Chinook salmon, three viable populations are needed. Thus, the downlisting criteria represent an initial key step along the path to recovering winter-run Chinook salmon.

ESU/DPS Delisting Criteria

In order for the Chinook salmon ESUs and the steelhead DPS to achieve recovery, Diversity Groups should display the following characteristics:

For the Winter-run Chinook salmon ESU:

- Three populations in the Basalt and Porous Lava Diversity Group at low risk of extinction

For the Spring-run Chinook salmon ESU:

- One population in the Northwestern California Diversity Group at low risk of extinction
- Two populations in the Basalt and Porous Lava Diversity Group at low risk of extinction
- Four populations in the Northern Sierra Diversity Group at low risk of extinction
- Two populations in the Southern Sierra Diversity Group at low risk of extinction
- Maintain multiple populations at moderate risk of extinction

For the California Central Valley steelhead DPS:

- One population in the Northwestern California Diversity Group at low risk of extinction
- Two populations in the Basalt and Porous Lava Flow Diversity Group at low risk of extinction
- Four populations in the Northern Sierra Diversity Group at low risk of extinction
- Two populations in the Southern Sierra Diversity Group at low risk of extinction
- Maintain multiple populations at moderate risk of extinction

For context, these ESU/DPS recovery criteria are shown in relation to historic and current conditions in Table 4-3. Although Table 4-3 does show that much improvement in the number and distribution of viable populations is needed, an encouraging take-away point is that these species can be recovered without achieving the historic condition. For example, a recovered spring-run Chinook salmon ESU requires nine viable populations, not the 19 that historically occurred in the Central Valley.

Table 4-3: Number of independent, viable populations of winter-run and spring-run Chinook salmon and steelhead by diversity group under historic and current conditions, relative to the recovery criteria. The recovery criteria also include maintenance of all existing dependent populations.

Diversity Group	**Historic, Current and Recovered Independent, Viable Populations - Total By Diversity Group**								
	Winter-Run			Spring Run			Steelhead		
	Historic	Current	Recovery Criteria	Historic	Current	Recovery Criteria	Historic	Current	Recovery Criteria
Basalt and Porous Lava	4	0	3	4	0	2	12	Unknown	2
Northwestern California	0	0	0	0	0	1	14	Unknown	1
Northern Sierra	0	0	0	11	1	4	21	Unknown	4
Southern Sierra	0	0	0	4	0	2	26	Unknown	2

4.4 Threat Abatement

The underlying causes of species declines should be controlled prior to delisting. These causes include all threats identified at the time of listing, as well as any new factors identified since listing. Since listing, numerous additional threats have been identified and prioritized for the ocean, migratory corridors, and for each of the Diversity Groups and individual populations of the winter-run and spring-run Chinook salmon ESUs, and the steelhead DPS within the Central Valley Domain (Introduction, Appendix B).

NMFS believes that the condition of habitat in the ESUs/DPS will be directly affected by actions that address threats to the habitat. Therefore, changes to habitat condition will be inferred by monitoring progress and the degree to which threats to habitat are improved or removed, at both the watershed and system scale. Therefore, abatement of threats will also meet these habitat objectives:

- The spatial distribution and productive capacity of freshwater, estuarine, and marine habitats should be sufficient to maintain viable populations identified for recovery;
- The diversity of habitats for recovered populations should provide sufficient resilience and redundancy to withstand expected natural disturbance regimes such as wildfires, floods, droughts and volcanic eruptions. Historic conditions represent a reasonable template for a viable population; the closer the habitat resembles the historic diversity, the greater the confidence in its ability to support viable populations; and
- At a large scale, habitats should be protected and restored, with a trend toward an appropriate range of attributes for salmonid viability. Freshwater, estuarine, and marine habitat attributes should be maintained in a non-deteriorating state.

4.4.1 Threats

Sacramento River Winter-run Chinook Salmon

Several factors have contributed to the decline of winter-run Chinook salmon through degradation of spawning, rearing, and migration habitats. The primary factors included in the listing of winter-run Chinook salmon were blockage of historical habitat by Shasta and Keswick dams, warm water releases from Shasta Dam, juvenile and adult passage constraints at RBDD, water exports in the southern Delta, heavy metal contamination from Iron Mountain Mine, high ocean harvest rates and entrainment in a large number of unscreened or poorly screened water diversions (NMFS 1997). Other factors include smaller water manipulation facilities and dams, loss of rearing habitat in the lower Sacramento River and Delta from levee construction, marshland reclamation, interaction with and predation by introduced species, adverse flow conditions, high summer water temperatures and vulnerability to drought (NMFS 1997). Since listing, some of these threats have been addressed, although numerous additional threats have been identified and prioritized (Appendix B).

Central Valley Spring-run Chinook Salmon

Listing factors and threats to Central Valley spring-run Chinook salmon fall into three broad categories: loss of historical spawning habitat; degradation of remaining habitat; and threats to genetic integrity. The last threat is to wild spawning populations resulting from spawning with FRFH spring-run Chinook salmon and naturally- and hatchery produced fall-run Chinook salmon. A complete prioritized list of the life stage-specific threats to the ESU is presented in Appendix B.

Central Valley Steelhead

Threats to Central Valley steelhead are similar to those for Central Valley spring-run Chinook salmon: loss of historical spawning habitat, degradation of remaining habitat, and threats to the genetic integrity of the wild spawning populations from hatchery steelhead production programs in the Central Valley. A complete prioritized list of life stage-specific threats to the DPS is presented in Appendix B.

4.4.2 Listing Factors

All threats to a species can be categorized into one of the five ESA listing factors:

1. The present or threatened destruction, modification, or curtailment of its habitat or range;
2. Overutilization for commercial, recreational, scientific, or educational purposes;
3. Disease or predation;
4. The inadequacy of existing regulatory mechanisms;
5. Other natural or manmade factors affecting its continued existence.

NMFS proposes that, to determine that the affected ESU/DPS is recovered to the point that it no longer requires the protections of the ESA, these five ESA listing factors should be addressed according to specific criteria identified for each of them in order to ensure that the underlying causes for listing the species are addressed.

It is likely that current threats may diminish or increase in severity due to anthropogenic or natural changes to the environment. Indeed, successful implementation of the actions in this recovery plan will ameliorate threats to the ESUs/DPS. Consequently, NMFS expects that the significance of threats will change over time. It is also possible that new threats may be identified. To track changes in the threat regime, every five years during the status reviews of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead, NMFS will evaluate whether the five listing factors have substantially changed.

4.4.3 Threat Abatement Criteria

NMFS is providing the specific threat abatement criteria listed below for each of the relevant listing factors to help to ensure that underlying causes of decline have been addressed and mitigated prior to considering a species for delisting. These threat abatement criteria correspond to the listing factors identified for winter- and spring-run Chinook salmon and steelhead in this Recovery Plan, and are related to each of the threats described in Appendix B.

- ☐ Populations have unobstructed access to Core 1, 2, and 3 watersheds and assisted access to primary watersheds for reintroduction that are obstructed. Man-made structures (e.g., bridges and water diversions) affecting these watersheds and in migratory habitat should meet NMFS' salmonid passage guidelines for stream crossings and screening criteria for anadromous salmonids (Listing Factors 1, 4, and 5)
- ☐ Utilization for commercial, recreational, scientific and educational purposes is managed, such that all core 1 populations meet the low extinction risk categories for abundance, productivity, and diversity (see table 4-1) (Listing Factor 2)
- ☐ Hatchery programs are operated so that all core 1 populations meet the low extinction risk criteria for hatchery influence (see table 4-1) (Listing Factors 3 and 5)
- ☐ Migration and rearing corridors meet the life-history, water quality and habitat requirements of the listed species, such that the corridor supports multiple viable populations (Listing Factors 1, 3, 4, and 5)

5.0 Recovery Actions

"Once there is a firm commitment and a strategy alternative has been decided upon, the third and final pillar of an effective salmon recovery effort is that a number of specific actions will be required to achieve effective implementation."

- Jeffrey J. Dose. Commitment, Strategy, Action: The Three Pillars of Wild Salmon Recovery *in* Salmon 2100: the future of wild Pacific salmon

This Recovery Plan establishes a strategic approach to recovery, which identifies critical recovery actions for the Central Valley, as well as watershed- and site-specific recovery actions. Watershed-specific recovery actions address threats occurring in each of the rivers or creeks that currently support spawning populations of the Sacramento River winter-run Chinook salmon ESU, the Central Valley spring-run Chinook salmon ESU, or the California Central Valley steelhead DPS. Site-specific recovery actions address threats to these species occurring within a migration corridor (e.g., San Francisco Bay or the Delta).

This Recovery Plan maintains a consistent strategic framework for the establishment of recovery goals and criteria, the identification and prioritization of threats, and the identification of recovery actions. As described in the Recovery Strategy chapter, the framework for ESU or DPS recovery includes goals and criteria directed at the diversity group and population levels. Similarly, the threats assessment framework for each ESU or DPS also was organized by diversity groups and populations. For the winter-run Chinook salmon ESU, threats were prioritized for the one Sacramento River population; for spring-run Chinook salmon and steelhead, threats were prioritized within each diversity group as well as within each population.

Three steps were used to prioritize recovery actions as they are presented in this plan. First, results from the threats assessment and prioritization process (described in Appendix B) were used to guide the identification of watershed- and site-specific recovery actions for each diversity group and population. This step prioritized recovery actions separately for each species. The second step was undertaken through consideration of specific actions that benefit multiple species and populations. Results from the second step included tables of recovery actions listed in descending order of priority by geographic region (e.g., Delta, mainstem Sacramento River, Battle Creek) based on multiple species benefits (see Appendix C). These first two steps were the only steps taken to prioritize recovery actions that were presented in the Co-Manager Review Draft Recovery Plan. Based on feedback from co-managers, it was apparent that the priority with which recovery actions should be undertaken was not clear.

To address this, we implemented a third step and prioritized each of the area- or watershed-specific recovery actions according to three categories. Priority 1 actions address the most important threats within an area (e.g., Pacific Ocean or Delta) or watershed; priority 2 actions address threats of moderate importance, and priority 3 actions are of lower importance to implement[7].

Actions were identified as priority 1, 2, or 3 based on the first two prioritization steps and on the best professional judgment of agency co-managers, including biologists from CDFW, DWR, USFWS, USFS, and NMFS.

A number of ecosystem and/or anadromous fish enhancement plans for the Central Valley, as well as input received from two recovery planning public workshops, held May 22nd and 24th, 2007 in Sacramento and Redding, respectively, have been used to identify recovery actions. These documents include:

- ☐ Final Restoration Plan for the AFRP (USFWS 2001)
- ☐ AFRP Planning Documents (AFRP Website 2005; AFRP Website 2006a; AFRP Website 2006b)
- ☐ Ecosystem Restoration Plan Planning Documents (CALFED 2006; CALFED 2007)
- ☐ Summary of Threats and Recovery Actions for Spring-run Chinook Salmon and Winter-run Chinook Salmon Recovery Actions. Sacramento Salmon and Steelhead Recovery Workshop (NMFS 2007c)
- ☐ Summary of Threats and Recovery Actions for Steelhead. Sacramento Salmon and Steelhead Recovery Workshop (NMFS 2007a)
- ☐ Steelhead Restoration and Management Plan for California (CDFW 1996)
- ☐ Lower Yuba River Revised Implementation Plan and Appendices (CALFED and YCWA 2005)
- ☐ Ecosystem Restoration Program Plan (ERPP) (CALFED 1999a)
- ☐ Restoring Central Valley Streams: A Plan for Action (CDFW 1993)
- ☐ Lower Yuba River Fisheries Management Plan (CDFW 1991a)

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[7] In NMFS' Public Draft Recovery Plan for the Evolutionarily Significant Units of Sacramento Winter-run Chinook Salmon and Central Valley Spring-run Chinook Salmon and the Distinct Population Segment of Central Valley Steelhead, October 2009, Appendix C, we described how we applied the recovery action priorities 1-3 described in NMFS recovery planning guidelines (55 FR 24296; June 15, 1990), which are also described in NMFS' Recovery Planning Guidance (NMFS 2010b), in developing recovery actions for each species addressed in this recovery plan. The recovery actions priorities 1-3 described here in this final recovery plan are based on grouping the recovery actions for all three listed species addressed in this recovery plan by area or watershed and prioritizing those actions as described here.

- ☐ Initial Fisheries and In-Stream Habitat Management and Restoration Plan for the Lower American River (Water Forum 2001)
- ☐ CALFED Bay/Delta Program Multi-Species Conservation Strategy. Final Programmatic EIS/EIR Technical Appendix (CALFED 2000a)
- ☐ Potential for Re-establishing a Spring-Run Chinook Salmon Population in the Lower Feather River (MWD 2005)
- ☐ Central Valley Salmon – A perspective on Chinook and Steelhead in the Central Valley of California (Williams 2006)
- ☐ What caused the Sacramento River fall Chinook stock collapse? (Lindley *et al*. 2009)
- ☐ Insights into the Problems, Progress, and Potential Solutions for Sacramento River Basin Native Anadromous Fish Restoration (Vogel 2011).

The recovery actions for this plan are presented in the tables below according to the following geographic organization:

- Throughout California or the Central Valley
- Pacific Ocean
- San Francisco, San Pablo, and Suisun bays
- Delta
- Mainstem Sacramento River
- Northwestern California Diversity Group
- Basalt and Porous Lava Diversity Group
- Northern Sierra Nevada Diversity Group
- Mainstem San Joaquin River
- Southern Sierra Nevada Diversity Group.

The implementation schedules that follow outline actions for the recovery program for the Sacramento River winter-run Chinook salmon ESU, the Central Valley spring-run Chinook salmon ESU, and the California Central Valley steelhead DPS, as set forth in this recovery plan. The schedules are a guide for meeting the recovery goals outlined in this plan. They indicate action priorities, action numbers, action descriptions, and duration of actions; the parties potentially involved in either funding or carrying out actions; and estimated costs. The listing of a party in an implementation schedule does not require the identified party to implement the action(s) or to secure funding for implementing the action(s).

Cost estimates are provided wherever practicable. In some cases, information essential to the development of even the roughest of estimates is unavailable, as described in detail below:

- There is no available information to estimate, even in the roughest of terms, the appropriate extent of an action:

- The essential quality or quantity of a determinative feature of an action can only be estimated after site-specific investigations are completed; NMFS is unaware of any existing site-specific investigations. This includes:

Gravel Augmentation	Estimate of amount of necessary gravel augmentation (if any) unavailable. Per unit cost is $11 to $72/cubic yard (Appendix D).
Wetland Habitat Restoration	Estimate of amount of habitat to be restored unavailable. Per unit cost is $75 to $100,000/acre (Appendix D Table HI-7).
Riparian Habitat Restoration	Estimate of amount of habitat to be restored unavailable. As identified in Appendix D, per unit costs vary depending on whether fencing, planting, irrigation, or invasive week control are needed.
Floodplain Habitat Restoration	Estimate of amount of habitat to be restored unavailable. Per unit cost is $5,000 to $80,000/acre (Appendix D Table HI-4)
Side Channel Habitat Restoration/Re-connection	Estimate of amount of habitat to be restored unavailable. Per unit cost is $20,000 to $300,000/acre (Appendix D Table HI-5)
Sediment retention projects.	Extent and method of sediment retention unavailable. See Appendix D, tables HU-1 through HU-4 for per unit costs for road de-commissioning, road upgrades, landslide/gully stabilization, and planting in upland areas.
Habitat acquisition/easements	Estimate of amount of habitat for acquisition, lease, or easement unavailable. Land acquisition costs per acre for California are presented by county in Appendix D, Table HA-3, and generally range from $200 to $20,000/acre. Conservation easement costs range from $209 to $730/acre (Appendix D).
Water acquisition for instream flow	Estimate of amount of water to be purchased unavailable. Cost per unit ranges from $43 to $88/af/year for upstream of Delta water purchases (Appendix D)

- With regard to the Delta (DEL-2.31) and San Francisco Bay (SFB-2.4) actions designed to promote nitrification and retention of NH4 through marsh restoration, it is not scientifically practicable to estimate how much restoration is needed to achieve the appropriate NH4 concentrations.

  - For the actions calling for projects to minimize predation at weirs, diversions, and related structures outside of the Delta[8], it is impracticable to provide cost estimates given the unknown but likely large number of man-made structures in the bays, and the Sacramento and San Joaquin river systems, many of which will require site-specific studies and adaptive management to identify unique solutions. After initial investigation, it is likely that the solution at one structure may apply to other structures of the same type (e.g., boat docks), in which case the overall cost of identifying and implementing solutions will diminish. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013)[9].
  - For actions calling for fish passage improvements at small agricultural diversions on a particular river or creek, the total number of diversions is unknown, making it impracticable to provide a total cost. Per unit cost of providing passage at agricultural diversion dams ranges from $30,000 to $1,356,500 (see Appendix D, page 21, table HB-4).

- Information on the cost of an action is known only to a third party, but such information has not been provided to NMFS by the third party at time of this Recovery Plan's publication;
- The action is so novel that no comparable actions can be identified and the action involves development or application of a new technology for which it is impracticable to provide a reasonable guess at the action's cost;
- The recommended action is based on the broad directives/guidelines of existing government plans and goals, for which no cost-estimate currently exists, but, due to the breadth of the existing directives/guidelines and their lack of specificity, it is impracticable to estimate the cost of their implementation. Two actions that fall into this category are: (1) Implement recommended actions from the National Ocean Council's National Ocean Policy Implementation Plan dated April 2013 [action PAO-2.3]; and (2) Implement the USEPA's Action Plan for addressing water quality concerns in the Bay/Delta [DEL-1.25].

Under the aforementioned circumstances, NMFS is unable to estimate practicably the cost of the action; accordingly, costs are identified as "To Be Determined" ("TBD"). Cost estimates will be determined as the currently unavailable information becomes available. Wherever practicable, NMFS has attempted to identify the following: 1) per-unit costs (particularly where the

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[8] The cost of minimizing predation at Delta structures was estimated at $50 million over 50 years (BDCP 2013). A similar type of cost analysis for which to base the cost of minimizing predation in San Francisco, San Pablo, and Suisun bays, and the Sacramento and San Joaquin river systems has not been conducted.

[9] BDCP (2013) estimated the annual cost of predator removal for 17 sites at roughly $640,000, therefore, each site would cost about $38,000 annually ($640,000/17).

unavailable quantum of information is the amount of habitat which must be addressed); 2) the cost of interim activities (including initial studies), which are the only estimable portion of an action and will help to provide the previously unavailable essential information, thereby ultimately leading to the action's ultimate cost estimate; and/or 3) a plan for determining the ultimate cost estimate.

In an effort to identify only the additional cost of species recovery, we considered what is already required under local, State, or Federal regulation, or settlement agreements, to be required actions, and thereby estimated them at $0. For example, the cost of an action required by a Reasonable and Prudent Alternative action which has already been adopted by an action agency is listed as $0. Also, actions were assumed to have no additional cost to recovery if the action would be accomplished under the existing work programs of government agencies and would not require an agency or group to acquire funding beyond their existing budgets. Because several federal and state agencies have significant budgets directed to natural resource protection in general, and anadromous salmonids in particular, many of the actions identified in this recovery plan will be implemented through those existing programs; as such, many actions are identified to cost $0, since the action will not cause agency budgets to expand.

The Southwest Fisheries Science Center (SWFSC) produced a Technical Memorandum providing information on costs associated with restoration activities. To help comply with the requirement to provide estimates of recovery costs, that Technical Memorandum has been appended to this recovery plan (Appendix D). Data from publicly available sources were used to obtain estimates of restoration costs for a variety of restoration activities. All costs described in Appendix D 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). Appendix D offers ranges of costs applicable at the ESU scale. Actual costs may vary widely from one watershed to another and across the extent of the Central Valley Domain due to potential differences in regional labor costs, property values, availability of expert contractors and materials, and permitting issues, etc. Many cost estimates for restoration activities in the Central Valley are specifically based on CALFED Ecosystem Restoration Program (ERP) implementation and/or contracted costs (most notably fish screening projects, gravel augmentation, channel restoration, bank stabilization, land acquisition, conservation easements, proposed watershed effectiveness monitoring, and a 5-dam decommissioning and removal project), so are specific to the Central Valley and are referenced as such in the Technical Memorandum. Also, levee-related and water purchase/lease activity cost estimates for the Central Valley were included in the report, based on information from DWR, county water agencies, and ERP. Irrigation ditch activity costs, including water control structures, were developed from information from county water agencies in the Central Valley. The rest of Appendix D contains data from the northernmost part of California, Oregon, Washington, and Idaho.

NMFS estimates that recovery for listed Central Valley salmon and steelhead, like for most of the ESA-listed Pacific Northwest salmon and steelhead, could take 50 to 100 years. Because there is an extensive list of actions that need to be undertaken to recover the listed Central Valley salmonids, there are many uncertainties involved in predicting the course of recovery and in estimating total costs and time to recovery. Such uncertainties include biological and ecosystem responses to recovery actions. Obtaining and evaluating cost estimates for recovery actions can be challenging, and projecting costs into the future becomes increasingly imprecise. NMFS believes it is impracticable to accurately estimate all projected actions and associated costs over 50 to 100 years, given the large number of economic, biological, and social variables involved, and that it is more appropriate to initially focus on the first 25 years of implementation. Because of these variables, cost projections become increasingly inaccurate with time. Most actions can be accomplished within this 25 year time frame. For actions that extend beyond 25 years (these actions are specifically identified in the description of the respective actions below), the cost over the first 25 years is provided, and it is assumed for lack of better information that those costs will continue for the remaining duration of the action. The cost estimates for actions in later years are likely much less accurate than estimates during earlier years of implementation.

The duration of an action in the implementation tables refers to how long the action will take to complete, as opposed to when the action will be initiated. When the exact number of years that it would take to complete an action could not be estimated, more general estimates were provided. The duration for most actions was identified using general estimates as short-term (i.e., roughly 10 years or less) or long-term (i.e., 11 to 25 years in most cases, up to 100 years where specifically noted).

Abbreviations key for the following tables:
ACWA: Association of California Water Agencies
AMR: American River
ANC: Antelope Creek
BAC: Battle Creek
BCC: Big Chico Creek
BLM: U.S. Bureau of Land Management
BUC: Butte Creek
CDFW: California Department of Fish and Wildlife
CEV: Central Valley
CLC: Clear Creek
COR: Cosumnes River
Corps: U.S. Army Corps of Engineers
CVP: Central Valley Project
CVRWQCB: Central Valley Regional Water Quality Control Board
DEC: Deer Creek
DEL: Delta
DRN: Delta Restoration Network
DSC: Delta Stewardship Council
DWR: California Department of Water Resources
FER: Feather River
FERC: Federal Energy Regulatory Commission
GCID: Glenn Colusa Irrigation District
HGMP: Hatchery and Genetic Management Plan
MER: Merced River
MIC: Mill Creek
MID: Merced Irrigation District

MOR: Mokelumne River
NGO: Non-governmental organization
NID: Nevada Irrigation District
NMFS: National Marine Fisheries Service
NFWF: National Fish and Wildlife Foundation
NRCS: Natural Resources Conservation Service
ODFW: Oregon Department of Fish and Wildlife
OID: Oakdale Irrigation District
PCWA: Placer County Water Agency
PG&E: Pacific Gas and Electric
PFMC: Pacific Fishery Management Council
PUC: Putah Creek
SAR: Sacramento River
SJR: San Joaquin River
SRCS: Spring-run Chinook salmon
STR: Stanislaus River
STC: Stony Creek
STE: Steelhead
SWP: State Water Project
SWRCB: State Water Resources Control Board
SWRFSC: NMFS Southwest Region Fisheries Science Center
SYRCL: South Yuba River Citizens League
TBD: To Be Determined
TCCA: Tehama-Colusa Canal Authority
THC: Thomes Creek
TID: Turlock Irrigation District
TNC: The Nature Conservancy
TUR: Tuolumne River
USBR: United States Bureau of Reclamation
USEPA: United States Environmental Protection Agency
USFS: United States Forest Service
USFWS: United States Fish and Wildlife Service
WRCS: Winter-run Chinook salmon
YCWA: Yuba County Water Agency
YUR: Yuba River

5.1 California and Central Valley Recovery Actions

Table 5-1. California and Central Valley Recovery Actions.

Action Area	Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
California	Implement Federal, State, and local initiatives and programs to improve water conservation in order to reduce state-wide water use by 20 percent per capita by 2020. This effort should take into account regional differences and find ways to improve agricultural and urban water use efficiency.	1	CA-1.1	WRCS ,SRCS, STE	Federal, State, County, and local governments	1,4,5	Short-term	TBD	TBD				TBD because the State Conservation Plan for the "20X2020" goal did not include an overall cost of the effort and the cost of the program can reasonably only be estimated by the state; numerous savings associated with investing in water conservation were provided, but an overall cost-benefit analysis was not conducted because of the large number of variables in play (DWR *et al.* 2010).
California	Implement the Global Warming Solutions Act (AB 32), the Sustainable Communities and Climate Protection Act (SB 375) and other smart growth measures to foster	1	CA-1.2	WRCS , SRCS, STE	Federal, State, County, and local governments	1,4,5	Long-term (beyond 25 years)	TBD	TBD	TBD	TBD	TBD	TBD because the number and scope of smart growth projects that will be implemented is indeterminate; it

Action Area	Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
	sustainable land use throughout California.												is assumed that smart growth and sustainable land use practices will need to be implemented in perpetuity in order to delist the species in this plan and keep them delisted.
Central Valley	Develop and implement an ecosystem based management approach that integrates harvest, hatchery, habitat, and water management, in consideration of ocean conditions and climate change (Lindley *et al*. 2009).	1	CEV-1.1	WRCS, SRCS, STE	NMFS, USFWS, CDFW, DWR, PFMC, SWRCB, USBR	1, 2, 5	Long-term	$1,086,360	$1,699,840	$1,965,015	$2,271,558	$2,625,921	$9,648,694
Central Valley	Support programs to provide educational outreach and local involvement in restoration and watershed stewardship, including programs like Salmonids in the Classroom, Aquatic Wild, Adopt a Watershed, school district environmental camps, and other programs teaching the effects of human land and water use on anadromous fish survival.	1	CEV-1.2	WRCS, SRCS, STE	NMFS, USFWS, USBR, USFS, CDFW, DWR	5	Long-term						Cost is provided in the education/outreach actions for specific watersheds.

Action Area	Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Central Valley	Provide additional funding for increased law enforcement to reduce illegal take of anadromous fish, ecologically harmful stream alterations, and water pollution and to ensure adequate protection for juvenile fish at pumps and diversions.	1	CEV-1.3	WRCS, SRCS, STE	CDFW, NMFS	4	Long-term	$12 million	$12 million	$12 million	$12 million	$12 million	$60 million
Central Valley	Implement the recommendations and guidelines of the California Hatchery Scientific Review Group (http://cahatcheryreview.com/).	1	CEV-1.4	WRCS, SRCS, STE	NMFS, USFWS, CDFW, USBR, DWR	5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD[10]
Central Valley	Implement a comprehensive Central Valley steelhead monitoring plan to better understand their abundance and distribution.	1	CEV-1.5	STE	NMFS, USFWS, CDFW, DWR, USBR	1	Long-term	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$7,500,000
Central Valley	Evaluate the relationship between resident and anadromous forms of O. mykiss to better understand the role that resident fish play in species maintenance and persistence.	1	CEV-1.6	STE	NMFS, USFWS, CDFW	1	Short-term	<$500,000	<$500,000				Cost will depend on study methodology, experimental design, number of samples needed, and other factors,

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[10] The Hatchery Scientific Review Group Cost (HSRG) did not develop cost estimates for their recommendations and guidelines. To implement the HSRG recommendations, hatchery coordination teams for each hatchery will be established; those teams will identify implementation costs.

Action Area	Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
													but overall it is anticipated to cost <$1,000,000
Central Valley	Implement and evaluate actions to minimize the adverse effects of exotic (non-native invasive) species (plants and animals) on the aquatic ecosystems used by anadromous salmonids.	1	CEV-1.7	WRCS, SRCS, STE	Department of Boating and Waterways	1,2,4	Long-term	$51,000,000	$125,000,000	$125,000,000	$125,000,000	$125,000,000	$551,000,000
Central Valley	Develop and implement State and National levee vegetation policies to maintain and restore riparian corridors.	1	CEV-1.8	WRCS, SRCS, STE	Corps, DWR, CDFW, NMFS	1,4	Long-term	$0	$0	$0	$0	$0	$0
Central Valley	Incorporate ecosystem restoration including breaching and setting back levees into Central Valley flood control plans (i.e., FloodSafe Strategic Plan and the Central Valley Flood Protection Plan).	1	CEV-1.9	WRCS, SRCS, STE	NMFS, USFWS, Corps, USBR, CDFW, DWR,	1,4	Long-term	$0	$0	$0	$0	$0	$0
Central Valley	Establish partnerships and agreements that promote water transactions, water transfers, shared storage, and integrated operations that benefit both species needs and water supply reliability.	1	CEV-1.10	WRCS, SRCS, STE	SWRCB, NFWF, ACWA, DWR, USBR	1,4,5	Short-term	$2,500,000	$2,500,000	$0	$0	$0	$5,000,000
Central Valley	Annually evaluate the harvest rate of Central Valley spring-run Chinook salmon and Sacramento River winter-run Chinook salmon in the ocean salmon	1	CEV-1.11	WRCS, SRCS	NMFS, PFMC, CDFW, USFWS	2	Long-term	Up to $750,000 for genetic analysis and reporting (Garza	Up to 750,000 for genetic analysis and reporting (Garza	Up to 750,000 for genetic analysis and reporting (Garza	Up to 750,000 for genetic analysis and reporting (Garza	Up to 750,000 for genetic analysis and reporting (Garza	Up to $3,750,000 for genetic analysis and reporting (Garza 2013); Up to $3,450,000 for

Action Area	Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
	fisheries (commercial and recreational) and modify fishing regulations as necessary to ensure that the fisheries impacts allow for the ESUs to recover.							2013); Up to $690,000 for sampling assuming two FTEs are needed to expand the existing sampling program[11]	2013); Up to $690,000 for sampling assuming two FTEs are needed to expand the existing sampling program	2013); Up to $690,000 for sampling assuming two FTEs are needed to expand the existing sampling program	2013); Up to $690,000 for sampling assuming two FTEs are needed to expand the existing sampling program	2013); Up to $690,000 for sampling assuming two FTEs are needed to expand the existing sampling program	sampling assuming two FTEs are needed to expand the existing sampling program
Central Valley	Continue to implement and improve comprehensive Chinook salmon monitoring to assess the viability of winter-run and spring-run.	1	CEV-1.12	WRCS,SRCS	CDFW, USFWS, DWR, USBR, NMFS	5	Long-term	$0	$0	$0	$0	$0	$0
Central Valley	Conduct a Central Valley-wide assessment of anadromous salmonid passage opportunities at large rim dams including the quality and quantity of upstream habitat, passage feasibility and logistics, and passage-related costs.	2	CEV-2.1	WRCS, SRCS, STE	NMFS, USFWS, USBR, USFS, CDFW, DWR	1,5	Short-term	$2,500,000	$2,500,000	$0	$0	$0	$5,000,000
Central Valley	Develop a Fishery Management and Evaluation Plan for inland fisheries to ensure that impacts of those fisheries on winter-run	2	CEV-2.2	WRCS, SRCS, STE	CDFW, NMFS	2	Short-term	$0	$0	$0	$0	$0	$0

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[11] Based on the May 2012 State Occupational Employment and Wage Estimates for California provided by the Bureau of Labor Statistics, the mean annual wage for a biologist is $69,000 (http://www.bls.gov/oes/current/oes_ca.htm#19-0000).

Action Area	Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
	Chinook salmon, spring-run Chinook salmon, and steelhead allow for these species to recover.												

5.2 Pacific Ocean Recovery Actions

Table 5-2. Pacific Ocean Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Re-evaluate and modify management measures, annual conservation objectives, harvest forecasting techniques, NMFS consultation standards for ESA listed salmon stocks, and consider implementing an ecosystem-based salmon fishery management plan that considers multi-trophic interactions, ocean currents, upwelling patterns, ocean temperatures, and other relevant factors.	1	PAO-1.1	WRCS, SRCS	NMFS, PFMC, CDFW	1,5	~ 10 years	$1,220,150	$1,410,493	$0	$0	$0	$2,630,643
Enhance water quality in the ocean and along the coast by continuing to promote and implement sustainable practices on land in ways that will improve the health of ocean water quality.	2	PAO-2.1	WRCS, SRCS, STE	NMFS, USFWS, PFMC, CDFW, WDFW, ODFW, county planning	1,5	Long-term	$0	$0	$0	$0	$0	$0
CDFW and National Marine Sanctuary Program should consider the ecological requirements of salmon and steelhead when designating sanctuaries	2	PAO-2.2	WRCS, SRCS, STE	CDFW, NMFS	4	Long-term	$0	$0	$0	$0	$0	$0
Implement recommended actions from the National Ocean Council's National Ocean Policy Implementation Plan dated April 2013	2	PAO-2.3	WRCS, SRCS, STE	NMFS, USFWS, PFMC, CDFW, WDFW, ODFW, county planning	4	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, the Ocean Policy Implementation Plan contains broad directives/guidelines, for which no cost-estimate currently exists, but, due to the breadth of the existing

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												directives/guidelines and their lack of specificity, it is impracticable to estimate the cost of their implementation.

5.3 San Francisco, San Pablo, and Suisun Bay Recovery Actions

Table 5-3. San Francisco, San Pablo, and Suisun Bay Reocery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement projects that improve wastewater and stormwater treatment throughout Suisun, San Pablo, and San Francisco bays and surrounding residential and commercial areas.	1	SFB-1.1	WRCS, SRCS, STE	SWRCB	1,5	Short-term	$1,545,000,000	$1,786,020,000	$0	$0	$0	$3,331,020,000
Protect, enhance, and restore a complex portfolio of habitats throughout Suisun, San Pablo, and San Francisco bays to provide cover and prey resources for migrating salmonids.	1	SFB-1.2	WRCS, SRCS, STE	NMFS, USFWS, Corps, DWR, CDFW	1, 3	Long-term						>$100 million (San Francisco Estuary Partnership 2007)
Improve the timing and extent of freshwater flow to the San Francisco Bay region to the	1	SFB-1.3	WRCS, SRCS, STE	USBR, DWR, CDFW, USFWS, NMFS, SWRCB, DSC	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
benefit of juvenile and adult salmonids by modifying water operations in the Central Valley to support flows that mimic the natural hydrograph.												
Fund and implement San Francisco Estuary Program's Comprehensive Conservation and Management Program aimed at the Estuary's aquatic resources.	1	SFB-1.4	WRCS, SRCS, STE	San Francisco Estuary Partnership	1, 4	Short-and Long-term components						$60-$80 million[12]
Cities, counties, districts, joint powers authority or other political subdivisions of the State involved with water management in Suisun, San Pablo, and San Francisco bays should	2	SFB-2.1	WRCS, SRCS, STE	CVRWQCB, Agriculture industry	1, 5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on the number of farmed acres that need drainage improvements in order to comply with CVRWQCB regulations. The cost estimates for management

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[12] The cost range of $60-$80 million was derived from the 2007 Comprehensive Conservation and Management Plan's Aquatic Resources section. The cost range was identified by summing the cost of actions that were not already covered by actions in this Recovery Plan.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
implement agricultural drainage management projects to treat, store, convey, and/or dispose of agricultural drainage.												practices may range from less than $20/acre to greater than $110/acre per year (CVRWQCB 2012)
Develop a long-term strategy for monitoring and regulating discharges from agricultural lands entering Suisun, San Pablo, and San Francisco bays.	2	SFB-2.2	WRCS, SRCS, STE	SWRCB	1,5	5 Years	$0	$0	$0	$0	$0	$0
Implement projects that would reduce anthropogenic inputs of NH4 to help achieve concentrations below 4 µmol L-1 in order to promote increased primary and secondary production (Dugdale *et al*. 2007).	2	SFB-2.3	WRCS, SRCS, STE	NMFS, USFWS, SWRCB, DWR, CDFW, Local agriculture groups	1,4,5	Long-term						$1 - $2 billion by 2020 to upgrade Sacramento County Regional Water Treatment Plant to reduce discharge limits for nitrogen, ammonia and pathogens[13].

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[13] Source: Sacramento Business Journal; http://www.bizjournals.com/sacramento/news/2012/12/05/state-water-sacramento-waste-water-treat.html

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement tidal marsh restoration projects to promote nitrification and retention of NH4 (Dugdale *et al*. 2007).	2	SFB-2.4	WRCS, SRCS, STE	NMFS, USFWS, Corps, CDFW, DWR, Various NGOs	1, 5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD because it is not scientifically practicable to estimate how much restoration is needed to achieve the appropriate NH4 concentrations
Evaluate whether predator control actions (e.g., fishery management or directed removal programs) can be effective at minimizing predation on juvenile salmon and steelhead in Suisun, San Pablo, and San Francisco bays; continue implementation if effective.	2	SFB-2.5	WRCS, SRCS, STE	USFWS, NMFS, USBR, CDFW, DWR, Various NGOs	3	Long-term	\$0-\$15,000,000[14]	\$0-\$15,000,000	\$0-\$15,000,000	\$0-\$15,000,000	\$0-\$15,000,000	\$0-\$75,000,000

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[14] If the action is limited to angling regulation changes, the cost is \$0; the upper bound (\$15,000,000) is based on the cost of the Columbia River pikeminnow bounty program (i.e., \$3,000,000/year on average) as identified in NMFS (2011). This recovery plan is not calling for a predator bounty program in the Central Valley, but for the purposes of cost estimation, the Columbia River program's cost is assumed to represent an upper bound for what predator control could cost in the Central Valley.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement studies to develop quantitative estimates of predation on juvenile salmonids by non-native species throughout Suisun, San Pablo, and San Francisco bays.	2	SFB-2.6	WRCS, SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	3	Short-term	$200,000-$400,000	$0	$0	$0	$0	$200,000-$400,000
Implement projects to identify predation "hot spots" throughout Suisun, San Pablo, and San Francisco bays and minimize losses of juvenile salmonids at those locations.	2	SFB-2.7	WRCS, SRCS, STE	DWR, USBR, CDFW, NMFS, USFWS	1,3	Long-term	$5,000-$50,000 for initial hot spot identification ; see total cost for potential site-specific costs	TBD	TBD	TBD	TBD	$5,000-$50,000 for initial hot spot identification. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												(BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).
Prevent in-bay disposal of contaminated sediments known to be detrimental to aquatic life.	2	SFB-2.8	WRCS, SRCS, STE	NMFS, Corps, USEPA	5	Long-term	$0	$0	$0	$0	$0	$0
Evaluate, and if feasible implement restoration projects that integrate upland, intertidal, and subtidal habitats; consider the following locations (from California State Coastal Conservancy *et al*. 2010): 1) San Pablo Bay: study potential resources and restoration activities in areas offshore from Sears Point, San Pablo	2	SFB-2.9	WRCS, SRCS, STE	California State Coastal Conservancy, CDFW, Corps, NMFS, USFWS	1	Long-term	TBD	TBD	TBD	TBD	TBD	$5,000-$50,000 for initial scoping and feasibility; total project cost TBD based on the type and amount of habitat that is restored. See Appendix D for unit costs.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Bay National Wildlife Refuge and Tubbs Island, and other restoration sites; 2) Corte Madera area: Muzzi Marsh, Corte Madera Ecological Reserve, Heard Marsh: existing wetlands and restored eelgrass, link to living shoreline project; 3) Richardson Bay: wetland restoration linked to existing oyster/eelgrass populations; 4) Breuner Marsh and Point Molate: link to Point San Pablo eelgrass bed; 5) Eastshore State Park: wetland restoration linked with oyster and eelgrass restoration, creek daylighting; 6) Central and North Bay Islands: link rocky habitat with eelgrass												

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
and oyster beds; and 7) South Bay Salt Pond sites; Eden Landing and other sites: link to southernmost eelgrass population, native oyster restoration.												
Develop and implement education and outreach programs to encourage stewardship of Suisun, San Pablo, and San Francisco bay habitats.	2	SFB-2.10	WRCS, SRCS, STE	NMFS, USFWS, CDFW, DWR	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Develop and implement studies to identify the significance and spatial distribution of marine mammal predation on	3	SFB-3.1	WRCS, SRCS, STE	NMFS, USFWS, USBR, Corps, CDFW, DWR	1,3	Short-term	$1.5 million - TBD					$1.5 million minimum up to TBD [15].

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[15] Based on an internet search, no projects have studied pinniped predation on juvenile salmon; as such there is no cost estimate to base the cost of this action on. The cost of studying pinniped predation on adult salmon is roughly estimated at $300,000 annually (Rub 2013); we assume that studying pinniped predation on juvenile salmon is more complicated than adults and thus will be at least as expensive. If the project were conducted for five years, the cost would be at least $1.5 million.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
adult and juvenile anadromous salmonids in Suisun, San Pablo, and San Francisco bays.												
On an annual basis, update the Office of Oil Spill Prevention and Response's Environmental Sensitivity Index maps and GIS maps to include the most current information on locations of sensitive or valued existing or restored subtidal habitats	3	SFB-3.2	WRCS, SRCS, STE	CDFW	3	Long-term	$0	$0	$0	$0	$0	$0

5.4 Delta Recovery Actions

Table 5-4. Delta Recovery Actions. Adaptively manage these suite of actions to achieve, at a minimum, through-Delta survival objectives of 57% for winter-run, 54% for spring-run, and 59% for steelhead originating from the Sacramento River; and 38% for spring-run and 51% for steelhead originating from the San Joaquin River (NMFS 2012b).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop, implement, and enforce new Delta flow objectives that mimic historic natural flow characteristics, including increased freshwater flows (from both the Sacramento and San Joaquin rivers) into and through the Delta and more natural seasonal and interannual variability.	1	DEL-1.1	WRCS, SRCS, STE	BDCP agencies and stake holders	1	Long-term, beginning in year 5	$0	$0	$0	$0	$0	$0
Reduce hydrodynamic and biological impacts of exporting water through Jones and Banks pumping plants.	1	DEL-1.2	WRCS, SRCS, STE	USBR, DWR, CDFW, NMFS	1	Long-term						$8.6 billion to $14.5 billion in capital costs (Stapler 2013); $85 million/year operating cost (Medellín-Azuara *et. al* 2013)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Provide pulse flows of approximately 17,000 cfs or higher as measured at Freeport periodically during the winter-run emigration season (i.e., December-April) to facilitate outmigration past Chipps Island.	1	DEL-1.3	WRCS, SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR, SWRCB	1	Long-term	$0	$0	$0	$0	$0	$0
Conduct landscape-scale restoration of ecological functions throughout the Delta to support native species and increase long-term overall ecosystem health and resilience (Whipple *et al*. 2012).	1	DEL-1.4	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	Long-term						$600 million to $13 billion

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement a targeted research and monitoring program to better understand the behavior, movement, and survival of steelhead, spring-run Chinook salmon, and winter-run Chinook salmon emigrating through the Delta from the Sacramento and San Joaquin rivers.	1	DEL-1.5	WRCS, SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	5	Long-term, up to 50 years						$627 million over 50 years[16].

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[16] This number is derived from the total estimated cost of monitoring and research as identified in the May 2013 administrative draft of BDCP. It is assumed that the cost estimate provided for BDCP research and monitoring provides a very rough approximation of the cost of action DEL-1.7.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Provide access to new floodplain habitat in the South Delta for migrating salmonids from the San Joaquin system.	1	DEL-1.6	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~20 years						~$950,000,000[17]
Restore, improve and maintain salmonid rearing and migratory habitats in the Delta and Yolo Bypass to improve juvenile salmonid survival and promote population diversity.	1	DEL-1.7	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	Long-term						Cost of this action is covered by actions DEL – 1.5 and DEL – 1.6.
Restore 17,000 to 20,000 acres of floodplain habitat (NMFS 2009b).	1	DEL-1.8	WRCS, SRCS, STE	USBR, DWR	1	Year 1 through 25	$0	$0	$0	$0	$0	$0

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[17] Assumes relocation of approximately 40 miles of existing lower San Joaquin River area levees over 50 years; cost estimate and associated assumptions taken from BDCP revised administrative draft dated May 2013

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Restore Liberty Island, Cache Slough, and the lower Yolo bypass (NMFS 2009b).	1	DEL-1.9	WRCS, SRCS, STE	USBR, DWR	1	Year 1 through 25	$0	$0	$0	$0	$0	$0
Enhance floodplain habitat in lower Putah Creek and along the toe drain (NMFS 2009b).	1	DEL-1.10	WRCS, SRCS, STE	USBR, DWR	1	Year 1 through 25	$0	$0	$0	$0	$0	$0
Implement the Putah Creek Enhancement Project (NMFS 2009b).	1	DEL-1.11	WRCS, SRCS, STE	USBR, DWR	1	Year 1 through 25	$0	$0	$0	$0	$0	$0
Implement the Lisbon Weir Fish Passage Enhancement Project (NMFS 2009b).	1	DEL-1.12	WRCS, SRCS, STE	USBR, DWR	1	Year 1 through 25	$0	$0	$0	$0	$0	$0
Implement the Prospect Island Tidal Habitat Restoration Project.	1	DEL-1.13	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	$16 million	$16 million				$32 million (Riordan 2013) Cost covered by Fish Restoration Program Agreement between CDFW and DWR.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement the Chipps Island Tidal Marsh Restoration Project.	1	DEL-1.14	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD	TBD				<= $15 million[18]
Implement the Eastern Decker Island Tidal Marsh Restoration Project.	1	DEL-1.15	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD	TBD				TBD, based on area of restoration and whether cost can be offset by re-use of excavated material[19]

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[18] Chipps Island has 732 acres available for restoration; assuming $20,100/acre for tidal marsh restoration, the maximum cost estimate is roughly $15 million.

[19] Decker Island was formed in the early 1900s when dredged material from the Sacramento River was deposited there. As such, the island is one of the highest places above sea level in the Delta. Restoration of Decker Island to provide fish habitat will involve considerable excavation, and there may or may not be value associated with the excavated material.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement the Southport Floodplain Restoration Project.	1	DEL-1.16	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	$55-$160 million (West Sacramento Area Flood Control Agency 2011)					$55-$160 million (West Sacramento Area Flood Control Agency 2011)
Implement the Dutch Slough Tidal Marsh Restoration Project.	1	DEL-1.17	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	$25 - $30 million in 2005 dollars (California State Coastal Conservancy 2006)					$25 - $30 million in 2005 dollars (California State Coastal Conservancy 2006)
Minimize the frequency, magnitude, and duration of reverse flows in Old and Middle River to reduce the likelihood that fish will be diverted from the San Joaquin or Sacramento rivers into the southern or central Delta (NMFS 2009b).	1	DEL-1.18	WRCS, SRCS, STE	USBR, DWR	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Continue to evaluate head of Old River barrier operations to identify and then implement the best alternative for maximizing survival of juvenile steelhead and spring-run Chinook salmon emigrating from the San Joaquin River.	1	DEL-1.19	WRCS, SRCS, STE	USBR, DWR	1	Short-term	$0	$0	$0	$0	$0	$0
Modify Delta Cross Channel gate operations and evaluate methods to control access to Georgiana Slough and other migration routes into the Interior Delta to reduce diversion of listed juvenile fish from the Sacramento River and the San Joaquin River into the southern or central Delta (NMFS (2009b).	1	DEL-1.20	WRCS, SRCS, STE	USBR, DWR	1	Year 1 through 25	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Through additional releases in the San Joaquin River system, augment flows in the southern Delta and curtail exports during critical migration periods (April-May), consistent with a ratio or similar approach.	1	DEL-1.21	WRCS, SRCS, STE	USBR, DWR, MID, Turlock Irrigation District, SWRCB	1	Long-term	$0	$0	$0	$0	$0	$0, no additional cost because additional releases will likely occur via SWRCB water quality objectives; and the export curtailments already occur through the RPA in the CVP/SWP Biological Opinion (NMFS 2009b)
Curtail exports when protected fish are observed at the export facilities to reduce mortality from entrainment and salvage (NMFS (2009b).	1	DEL-1.22	WRCS, SRCS, STE	USBR, DWR	1,5	Year 1 through 25	$0	$0	$0	$0	$0	$0
Improve fish screening and salvage operations to reduce mortality from entrainment and salvage (NMFS (2009b).	1	DEL-1.23	WRCS, SRCS, STE	USBR, DWR	1,5	Year 1 through 25	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Establish a Delta operations technical group to assist in determining real-time operational measures, evaluating the effectiveness of the actions, and modifying them if necessary (NMFS (2009b).	1	DEL-1.24	WRCS, SRCS, STE	USBR, DWR	1,5	Year 1 through 25	$0	$0	$0	$0	$0	$0
Implement the USEPA's Action Plan for addressing water quality concerns in the Bay/Delta (USEPA 2012).	1	DEL-1.25	WRCS, SRCS, STE	USEPA, SWRCB	1,5	Long-term						TBD[20]
Design and implement a project(s) to: (1) allow adult salmonids (and sturgeon) from the Sacramento Deep Water Ship Channel	1	DEL-1.26	WRCS, SRCS, STE	Corps	1	Short-term	TBD; this action requires a yet to be determined unique engineering solution. Initial feasibility	TBD				TBD; this action requires a yet to be determined unique engineering solution. Initial feasibility

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[20] The action plan contains seven components, six of which have dedicated funding and would result in no additional cost. A component calling for advanced water quality monitoring and assessment will require some additional funding, but it was not practicable until the multiple entities involved in this component have coordinated to conduct a funding assessment; a funding assessment for this component is planned.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
(SDWSC) to pass the channel gates and enter the Sacramento River (or block adult salmonids from entering the SDWSC); and (2) minimize fish passage from the Sacramento River into the SDWSC.							study is assumed to cost at least $50,000.					study is assumed to cost at least $50,000.
Identify and implement projects designed to improve passage and habitat conditions in the Stockton Deep Water Ship Channel.	1	DEL-1.27	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1	Long-term	$0	$0	$0	$0	$0	$0
Implement projects to minimize predation at weirs, diversions, and related structures in the Delta.	1	DEL-1.28	WRCS, SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	3	Long-term	$5 million	$5 million	$5 million	$5 million	$5 million	$50 million over 50 years (BDCP 2013)

Recovery Action	**Action Priority**	**Action ID**	**Species**	**Potential Collaborators**	**Listing Factor(s) Addressed**	**Duration**	**~ Cost FY1-5**	**~ Cost FY6-10**	**~ Cost FY11-15**	**~ Cost FY16-20**	**~ Cost FY21-25**	**Total ~Cost**
Establish Vernalis flow criteria that incorporate the flow schedules of the San Joaquin River and tributaries in order to increase juvenile salmonid outmigration survival.	1	DEL-1.29	WRCS, SRCS, STE	USBR, DWR, CDFW, NMFS, USFWS, MID, TID, SWRCB	1	Long-term	$0	$0	$0	$0	$0	$0
Implement integrated flood control improvements along McCormack-Williamson Tract that benefit flood management, aquatic and terrestrial habitats, and species and ecological processes.	2	DEL-2.1	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	$5,000,000	$5,000,000	$0	$0	$0	$10,000,000
Implement restoration projects for Lindsey and Barker sloughs.	2	DEL-2.2	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	$400,000 to $3,400,000 (Solano Land Trust *et al*. 2006)					$400,000 to $3,400,000 (Solano Land Trust *et al*. 2006)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Evaluate the potential effects of reconnecting Elk Slough to the Sacramento River, and if the evaluation suggests that habitat conditions for salmonids would improve, then implement a project to carry out the reconnection (Siegel 2007).	2	DEL-2.3	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	$2,600,000	$2,600,000	$0	$0	$0	$5,200,000
Improve habitat for juvenile salmonids in Elk, Sutter, and Steamboat sloughs (Siegel 2007).	2	DEL-2.4	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD, based on type and extent of habitat improvements; initial study is expected to cost at least $50,000.	TBD				TBD, based on type and extent of habitat improvements; initial study is expected to cost at least $50,000.
Re-establish hydrologic connectivity between historical Stone Lakes floodplain and the Sacramento River with a design that minimizes juvenile stranding.	2	DEL-2.5	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD; unaware of similar projects to base cost on; initial feasibility study would cost at least $50,000	TBD				TBD; unaware of similar projects to base cost on; initial feasibility study would cost at least $50,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Restore tidal wetlands and associated habitats at Brannan Island State Park, northeast tip of Sherman Island, along Seven-Mile slough, and the southwest tip of Twitchell Island.	2	DEL-2.6	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD, based on type and extent of habitat improvements; initial study is expected to cost at least $50,000.	TBD				TBD, based on type and extent of habitat improvements; initial study is expected to cost at least $50,000.
Implement the Grizzly Slough Floodplain and Riparian Habitat Restoration Project.	2	DEL-2.7	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years						$250,000 - $4,000,000[21]

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[21] DWR website identifies 50 additional acres for floodplain restoration at Grizzly Slough (http://www.water.ca.gov/floodsafe/fessro/environmental/dee/grizzlyslough.cfm).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement the Meins Landing Tidal Habitat Restoration Project.	2	DEL-2.8	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD, based on extent and type of habitat restoration; initial study is expected to cost at least $50,000.	TBD				TBD, based on extent and type of habitat restoration; initial study is expected to cost at least $50,000.
Implement the Hill Slough Tidal Habitat Restoration Project.	2	DEL-2.9	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD, based on extent and type of habitat restoration; initial study is expected to cost at least $50,000.	TBD				TBD, based on extent and type of habitat restoration; initial study is expected to cost at least $50,000.
Implement the Tule Red Restoration Project.	2	DEL-2.10	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD, based on extent and type of habitat restoration; initial study is expected to cost at least $50,000.	TBD				TBD, based on extent and type of habitat restoration; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement the Rush Ranch Tidal Habitat Restoration Project.	2	DEL-2.11	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS	1	~10 years	TBD, based on extent and type of habitat restoration; initial study is expected to cost at least $50,000.	TBD				TBD, based on extent and type of habitat restoration; initial study is expected to cost at least $50,000.
Evaluate whether predator control actions (e.g., fishery management or directed removal programs) can be effective at minimizing predation on juvenile salmon and steelhead in the Delta.	2	DEL-2.12	WRCS, SRCS, STE	CDFW, Sport fishing community	3	Long-term						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).
Modify existing water control structures to maintain flows through isolated ponds in the Yolo Bypass to minimize fish stranding, particularly following the cessation of flood flows over the Fremont Weir.	2	DEL-2.13	WRCS, SRCS, STE	TCCA, USBR, DWR, CDFW, NMFS, USFWS	1	Short-term	TBD, based on type and number of modifications; initial study is expected to cost at least $50,000.	TBD				TBD, based on type and number of modifications; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Modify Reclamation District 2068 levees to provide rearing and predator refuge habitat for juvenile salmonids.	2	DEL-2.14	WRCS, SRCS, STE	Corps	1	~10 years	TBD	TBD				TBD based on the amount and type of habitat to be restored.
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap.	2	DEL-2.15	WRCS, SRCS, STE	Corps	1	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement to stop illegal rip rap applications in the Delta.	2	DEL-2.16	WRCS, SRCS, STE	CDFW, NMFS, Corps	1,4	Long-term						Cost is covered under action # COC-2.9 ($1,750,000)
Curtail further development in active Delta floodplains through zoning restrictions, county master plans and other Federal, State, and county planning and regulatory processes, and land protection agreements.	2	DEL-2.17	WRCS, SRCS, STE	Contra Costa, Solano, Yolo, Sacramento, and San Joaquin counties. DRN, DSC	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Prioritize and screen Delta diversions.	2	DEL-2.18	WRCS, SRCS, STE	DSC, DRN, Corps, DWR, USBR, USFWS, CDFW, NMFS, local counties	1	Long-term	$100,000 for monitoring program; screening costs for Delta Diversions are TBD.	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).
Implement management actions for addressing invasive aquatic species including those described in the California Aquatic Invasive Species Management Plan.	2	DEL-2.19	WRCS, SRCS, STE	Department of Boating and Waterways	1	Long-term	$51,000,000	$125,000,000	$125,000,000	$125,000,000	$125,000,000	$551,000,000
Implement projects that improve wastewater and stormwater treatment throughout the Delta and surrounding residential and commercial areas.	2	DEL-2.20	WRCS, SRCS, STE	NMFS, USFWS, SWRCB, CVRWCB, DWR, CDFW, Local governments	1, 5	Long-term						Cost is covered under action SFB-2.3 ($1 - $2 billion by 2020 to upgrade Sacramento County Regional Water Treatment Plant to reduce discharge limits for

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												nitrogen, ammonia and pathogens[22]).
Review and potentially update the through-Delta survival rate objectives included in this recovery plan as new information is obtained.	2	DEL-2.21	WRCS, SRCS, STE	NMFS, CDFW, DSC, USFWS	1	Long-term	$0	$0	$0	$0	$0	$0
Develop regional agreements on geographic boundaries for estimating through-Delta survival, and appropriate technologies for collecting the required empirical data.	2	DEL-2.22	WRCS, SRCS, STE	NMFS, CDFW, DSC, USFWS	5	Long-term	$0 for agreement development; TBD for technology development	$0 for agreement development; TBD for technology development	$0 for agreement development; TBD for technology development	$0 for agreement development; TBD for technology development	$0 for agreement development; TBD for technology development	$0 for agreement development; TBD for technology development

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[22] Source: Sacramento Business Journal; http://www.bizjournals.com/sacramento/news/2012/12/05/state-water-sacramento-waste-water-treat.html

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Explore and support the development of existing or innovative approaches and tools for centralized tracking of restoration efforts in the Delta.	2	DEL-2.24	WRCS, SRCS, STE	Delta Conservancy, DWR, USBR, CDFW, NMFS Delta land owners	1,5	Long-term	$0	$0	$0	$0	$0	$0
Coordinate efforts to identify and highlight funding needs for restoration planning, monitoring, tracking, synthesis and adaptive management in the near and long term.	2	DEL-2.25	WRCS, SRCS, STE	Delta Conservancy, DWR, USBR, CDFW, NMFS Delta land owners	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop outreach strategies and mechanisms to ensure the Delta community, the legislature, appropriate agencies and the public are regularly updated on actions related to restoration and recovery.	2	DEL-2.26	WRCS, SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR, Various NGOs	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement education and outreach programs to encourage river stewardship.	2	DEL-2.27	WRCS, SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR, Various NGOs	1,5	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Cities, counties, districts, joint powers authority or other political subdivisions involved with water management should implement agricultural drainage management projects to treat, store, convey, and/or dispose of agricultural drainage.	2	DEL-2.28	WRCS, SRCS, STE	CVRWQCB, Delta farmers	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on the number of farmed acres that need drainage improvements in order to comply with CVRWQCB regulations. The cost estimates for management practices may range from less than $20/acre to greater than $110/acre per year (CVRWQCB 2012)
Continue development of a long-term strategy for monitoring and regulating discharges from agricultural lands to protect waters within the Central Valley, including	2	DEL-2.29	WRCS, SRCS, STE	CVRWQCB	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
enforcing the regulations.												
Increase monitoring and enforcement in the Delta to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants (SWRCB 2007).	2	DEL-2.30	WRCS, SRCS, STE		1,5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)
Implement projects that would reduce anthropogenic inputs of NH4 to help achieve concentrations below 4 µmol L-1 in order to promote increased primary and secondary production (Dugdale *et al*. 2007).	2	DEL-2.31	WRCS, SRCS, STE	Sacramento Regional County Sanitation District	1	Long-term						Cost is covered under action SFB-2.3 ($1 to $2 billion by 2020).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Continue to operate the Suisun Marsh Salinity Control Structure with the boat lock open in order to allow fish passage in and out of Suisun Marsh.	3	DEL-3.1	WRCS, SRCS, STE	DWR and USBR	1,5	Long-term	$0	$0	$0	$0	$0	$0

5.5 Mainstem Sacramento River Recovery Actions

Table 5-5. Mainstem Sacramento River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement a program to reintroduce winter-run Chinook salmon, spring-run Chinook salmon, and steelhead to historic habitats upstream of Shasta Dam. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term reintroduction program.	1	SAR-1.1	WRCS, SRCS, STE	USBR, NMFS, CDFW, DWR, USFWS, PG&E, FERC	1,5	Long-term:	$200,000	$4,000,000	$15,000,000	$17,000,000	$14,000,000	$50,200,000
Restore and maintain riparian and floodplain ecosystems along both banks of the Sacramento River to provide a diversity of habitat types including riparian forest, gravel bars and bare cut banks, shady vegetated banks, side	1	SAR-1.2	WRCS, SRCS, STE	USBR, NMFS, CDFW, DWR, USFWS	1,4	~10 years	$19,532,500	$22,579,570	$0	$0	$0	$42,112,070

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
channels, and sheltered wetlands, such as sloughs and oxbow lakes following the guidance of the Sacramento River Conservation Area Handbook (Resources Agency of the State of California 2003).												
Identify and implement any required projects to assure the M&T Ranch water diversion is adequately screened to protect winter-run Chinook salmon, spring-run Chinook salmon, and steelhead.	1	SAR-1.3	WRCS, SRCS, STE	NMFS, USBR, USFWS, and M&T Ranch	1,5	< 5 years	$9,500,000	$0	$0	$0	$0	$9,500,000
Develop and implement a river flow management plan for the Sacramento River downstream of Shasta and Keswick dams that considers the effects of climate change and balances beneficial uses with the flow and water temperature	1	SAR-1.4	WRCS, SRCS, STE	NMFS, USBR, USFWS, DWR, CDFW	1,5	Short-term	$740,150	$0	$0	$0	$0	$740,150

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
needs of winter-run Chinook salmon, spring-run Chinook salmon, and steelhead. The flow management plan should consider the importance of instream flows as well as the need for floodplain inundation (Williams *et al*. 2009).												
Install NMFS-approved, state-of-the-art fish screens at the Tehama Colusa Canal diversion. Implement term and condition 4c from the biological opinion on the Red Bluff Pumping Plant Project, which calls for monitoring, evaluating, and adaptively managing the new fish screens at the Tehama Colusa Canal diversion to ensure the screens are working properly and impacts to listed species are minimized (NMFS	1	SAR-1.5	WRCS, SRCS, STE	DWR, USBR, TCCA	1,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
2009c).												
Develop and implement a long-term gravel augmentation plan consistent with CVPIA to increase and maintain spawning habitat for winter-run Chinook salmon, spring-run Chinook salmon, and steelhead downstream of Keswick Dam.	1	SAR-1.6	WRCS, SRCS, STE	CDFW, NMFS, USBR, USFWS	1,5	Long-term	$380,000	$439,280	Up to ~$500,000	Up to ~$500,000	Up to ~$500,000	Up to ~$2,319,280
Develop and implement a secondary fish trapping location for the Livingston Stone NFH winter-run Chinook salmon supplementation	1	SAR-1.7	WRCS, SRCS, STE	NMFS, USFWS, USBR	1,5	Long-term						Up to $27,400,000 to build secondary facility[23]; Assuming the facility will require two to ten FTE's, operational costs

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[23] The Minto Salmon and Steelhead Collection Facility on western Oregon's North Santiam River was rebuilt at a cost of $27,400,000 (http://www.cbbulletin.com/426310.aspx).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
program to provide increased opportunity to capture a spatially representative sample and target numbers of broodstock.												will range from approximately $138,600 to $693,000 per year[24]
Study the merits and investigate feasibility of modifying the altered channel morphology at Turtle Bay in Redding to eliminate the gravel "sink" created by historic gravel mining activities. If the study suggests that it is feasible to modify the channel morphology such that it is beneficial to spawning gravel augmentation efforts, then implement the channel modification project.	1	SAR-1.8	WRCS, SRCS, STE	USFWS, NMFS, DFG, USBR	1	Long-term	>$110,000					>$110,000[25]

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[24] Based on the May 2012 State Occupational Employment and Wage Estimates for California provided by the Bureau of Labor Statistics, the mean annual wage for a biologist is $69,000 (http://www.bls.gov/oes/current/oes_ca.htm#19-0000).

[25] A channel morphology study on the Yuba River was estimated at between $110,000 and $150,000; because action SAR-1.8 calls for studying the channel morphology and potentially modifying the channel, the Turtle Bay action will be at least as expensive as the Yuba project.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Investigate mechanisms to influence/stimulate anadromy in *O. mykiss* in the upper Sacramento River.	1	SAR-1.9	STE	NMFS SWRFSC, CDFW	1,5	~5 years	$100,000 - $1,000,000	$0	$0	$0	$0	$100,000 - $1,000,000
Operate and maintain temperature control curtains in Lewiston and Whiskeytown Reservoirs to minimize warming of water from the Trinity River and Clear Creek.	1	SAR-1.10	WRCS, SRCS, STE	USBR	1,5	Long-term	$150,000 for inspections. Up to $~17,000 to repair one rip in the curtain; repair cost TBD based on inspections	$150,000 for inspection. Up to $~17,000 to repair one rip in the curtain; repair cost TBD based on inspections	$150,000 for inspection. Up to $~17,000 to repair one rip in the curtain; repair cost TBD based on inspections	$150,000 for inspection. Up to $~17,000 to repair one rip in the curtain; repair cost TBD based on inspections	$150,000 for inspection. Up to $~17,000 to repair one rip in the curtain; repair cost TBD based on inspections	$750,000 for inspection; repair costs TBD based on inspections. Whiskeytown curtain was replaced in 2012 at a cost of $3.5 million. Replacement needed roughly every 15 years. Lewiston curtain is less susceptible to damage than Whiskeytown, but if it needs to be replaced, cost would be ~$1.5 million.
Avoid full power peaking at Trinity and Carr Power plants during sensitive periods for water temperatures to reduce water temperatures in the Sacramento River. Evaluate impacts of power	1	SAR-1.11	WRCS, SRCS, STE	USBR, USFWS, NMFS	5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD; NMFS is in the process of obtaining the information from USBR.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
peaking operations in the Trinity River, Sacramento River and Clear Creek.												
In an adaptive management context, implement short- and long-term solutions to minimize the loss of adult Chinook salmon and steelhead in the Yolo bypass, and Colusa and Sutter-Butte basins. Solutions include: · Re-operating, to the extent feasible, the Knights Landing outfall gates to help prevent listed fish from entering the Colusa Basin (short-term); . Monitoring the Colusa and Sutter-Butte basins during winter and spring for adult salmon presence, and conducting fish rescues as necessary (short-term);	1	SAR-1.12	WRCS, SRCS, STE	CDWF, DWR, USFWS, NMFS, USBR, GCID, RD 108	1	Short- and long-term components	If fish rescues are needed, cost is estimated at ~$100,000 based on the 2013 rescue. Providing and/or improving fish passage through the Yolo Bypass and Sutter Bypass is required by the 2009 CVP/SWP biological opinion and therefore is estimated at $0. NMFS is in the process of obtaining cost information for this	Same as for FY1-5.	Same as for FY1-5.	Same as for FY1-5.	Same as for FY1-5.	If fish rescues are needed, cost is estimated at ~$100,000 based on the 2013 rescue. Providing and/or improving fish passage through the Yolo Bypass and Sutter Bypass is required by the 2009 CVP/SWP biological opinion and therefore is estimated at $0. NMFS is in the process of obtaining cost information for this action from DWR

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
. Evaluating other potential Colusa Basin Drain entry points for adult salmon along the Sacramento River above Knights Landing, and implementing fish exclusion solutions if necessary (short-term); . Providing and/or improving fish passage through the Yolo Bypass and Sutter Bypass allowing for improved adult salmonid re-entry into the Sacramento River (long-term); and . Installing fish exclusion devices at strategic locations to reduce migration of listed, adult salmonids into the Colusa Basin Drain complex (long-term); locations include,							action from DWR					

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
but are not limited to: · in the Yolo Bypass Tule Canal or Knights Landing Ridge Cut, downstream of Wallace Weir; · just upstream of the Knights Landing outfall gates (Colusa Basin side), provided that the reoperation of the Knights Landing outfall gates and/or the exclusionary device downstream of Wallace Weir fail to block migration of adults into the Colusa Basin Drain; and · at the Knights Landing outfall gates (Sacramento River side), provided that the reoperation of the Knights Landing outfall gates is ineffective.												
Identify management targets for Yolo and Sutter bypass inundation timing,	1	SAR-1.13	WRCS, SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR,	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
frequency, magnitude, and duration that will maximize the growth and survival of juvenile winter-run Chinook salmon and spring-run Chinook salmon; and then manage the bypasses to those targets.				SWRCB								
Ensure that river bank stabilization projects along the Sacramento River utilize bio-technical techniques that restore riparian habitat, rather than solely using the conventional technique of adding rip rap.	2	SAR-2.1	WRCS, SRCS, STE	Corps, USBR, NMFS, USFWS, DWR, CDFW,	1,5	Long-term	$0	$0	$0	$0	$0	$0
Curtail further development in active Sacramento River floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	2	SAR-2.2	WRCS, SRCS, STE	Corps, NMFS, USFWS, DWR, CDFWS, Local governments	1,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Increase monitoring and enforcement to minimize illegal streambank alterations along the Sacramento River.	2	SAR-2.3	WRCS, SRCS, STE	Corps, SWRCB, CDFW	1,5	Long-term						Cost is covered under action # COC-2.9
Develop and implement education and outreach programs to encourage river stewardship along the Sacramento River. Implement outreach projects to educate the public regarding the salmon life cycle including how to identify a salmon redd.	2	SAR-2.4	WRCS, SRCS, STE	USBR, NMFS, USFWS, CDFW, DWR, Various NGOs	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Improve wastewater and stormwater treatment in residential, commercial, and industrial areas within the Sacramento River watershed.	2	SAR-2.5	WRCS, SRCS, STE	NMFS, USFWS, SWRCB, CVRWCB, DWR, CDFW, Local governments	1, 5	Long-term						Cost partially covered in DEL-2.20 ($1-$2 billion). Other costs TBD based on site-specific evaluations, each of which could range up to $100,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Increase monitoring and enforcement to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants entering the Sacramento River.	2	SAR-2.6	WRCS, SRCS, STE	Corps, SWRCB, USBR, CDFW	4,5	Long-term	\$350,000[26]	\$350,000	\$350,000	\$350,000	\$350,000	\$1,750,000
Develop a long-term strategy for reducing water quality impacts to the Sacramento River from agricultural lands. The strategy should include incentive-based projects to promote implementation of best management practices as well as enforcement actions to ensure compliance with existing regulations.	2	SAR-2.7	WRCS, SRCS, STE	SWRCB, CVRWQCB, USEPA	5	Long-term	\$0	\$0	\$0	\$0	\$0	\$0

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[26] Assuming 1 new full time equivalent at \$70,000/year, based on the average salary for a California Fish and Game warden as identified on the Bureau of Labor statistics website (http://www.bls.gov/oes/current/oes_ca.htm#19-0000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement projects that promote native riparian (e.g., willows) species including eradication projects for non-native species (e.g., Arundo, tamarisk).	2	SAR-2.8	WRCS, SRCS, STE	NMFS, USBR Districts, DWR, Corps	5	Long-term	$0	$0	$0	$0	$0	$0
Implement studies designed to quantify the amount of predation on winter-run Chinook salmon, spring-run Chinook salmon, and steelhead by non-native species in the Sacramento River. If the studies identify predator species and/or locations contributing to low salmonid survival, then evaluate whether predator control actions (e.g., fishery management or directed removal programs) can be effective at minimizing predation on juvenile salmon and steelhead in	2	SAR-2.9	WRCS, SRCS, STE	NMFS SWRFSC, CDFW	2	Long-term						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
the Sacramento River; continue implementation if effective.												
Implement projects to minimize predation at weirs, diversions, and related structures in the Sacramento River.	2	SAR-2.10	WRCS, SRCS, STE	NMFS, CDFW, DWR, USFWS, USBR, Corps	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												cost about $38,000 annually (BDCP 2013).
Improve instream refuge cover in the Sacramento River for salmonids to minimize predatory opportunities for striped bass and other non-native predators.	2	SAR-2.11	WRCS, SRCS, STE	USCOE, DWR, NMFS	1,3,4	Long-term	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and placement method. Initial scoping to address those issues would cost at least $50,000. See Table H1-2 in Appendix D for cost per unit for various projects.	TBD	TBD	TBD	TBD	TBD, based on the # of sites, amount of material needed, type of material, location of source material (onsite vs. imported), and placement method. Initial scoping to address those issues would cost at least $50,000. See Table H1-2 in Appendix D for cost per unit for various projects.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop an incentive-based entrainment monitoring program in the Sacramento River designed to work cooperatively with diverters to develop projects or actions in order to minimize pumping impacts.	2	SAR-2.12	WRCS, SRCS, STE	USFWS, USBR, Family Alliance, DWR, CDFW, farmers, local govt, Northern California Water Association	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop and apply alternative diversion technologies that reduce entrainment.	2	SAR-2.13	WRCS, SRCS, STE	USBR and agricultural interests	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD. ·This action involves development of a new technology such that is impracticable to provide a reasonable estimate of the action's cost.
Maintain remedial actions to reduce heavy metal containments from Iron Mountain Mine.	2	SAR-2.14	WRCS, SRCS, STE	USEPA, NMFS, DFG, USBR	5	Long-term	$0	$0	$0	$0	$0	$0
Restore the current Lake Red Bluff footprint to riparian habitat, consistent with flood control needs.	2	SAR-2.15	WRCS, SRCS, STE	USFS, USBR, USFWS	1	Short-term	$5,000-$6,750,000, depending on whether just a small portion or the entire footprint is restored.	$0	$0	$0	$0	$5,000-$6,750,000, depending on whether just a small portion or the entire footprint is restored.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop criteria and a process for phasing out the Livingston Stone winter-run Chinook salmon hatchery program as winter-run recovery criteria are reached. This hatchery program is expected to play a continuing role as a conservation hatchery to help recover winter-run Chinook salmon.	2	SAR-2.16	WRCS, SRCS, STE	USFWS, NMFS, CDFW	5	Short-term	$0	$0	$0	$0	$0	$0
Evaluate and reduce stranding of juvenile Chinook in side channels in the reach from Keswick Dam to Colusa, due to flow reductions from Keswick Reservoir, by increasing or stabilizing releases from the reservoir.	2	SAR-2.17	WRCS, SRCS, STE	USBR, USFWS, DFG	1,5	Short-term	$0	$0	$0	$0	$0	$0
Using an adaptive approach and pilot studies, determine if instream habitat for juvenile rearing is limiting salmonid populations, by placing juvenile-rearing-enhancement	2	SAR-2.18	WRCS, SRCS, STE	NMFS SWRFSC, DFG, USFWS	1	Short-term	TBD based on the scope of pilot and full studies; pilot study is assumed to cost at least $50,000; overall cost	TBD	$0	$0	$0	TBD based on the scope of pilot and full studies; pilot study is assumed to cost at least $50,000; overall cost will also depend on the amount and type of instream habitat that is

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
structures in the Sacramento River. If found to be limiting, add large woody debris / coarse organic material to the upper, middle and lower reaches of Sacramento River to increase the quantity and quality of juvenile rearing habitat.							will also depend on the amount and type of instream habitat that is restored, if any.					restored, if any.
Assess the impacts to development, migration, and predation on juvenile salmonids from artificial light sources (e.g., Sundial Bridge) and take appropriate action based on the findings.	2	SAR-2.19	WRCS, SRCS, STE	DFG, local govt.	1,5	Short-term	$0	$0	$0	$0	$0	$0

5.6 Northwestern California Diversity Group Recovery Actions

5.6.1 Clear Creek Recovery Actions

Table 5-6. Clear Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration (years)	~Cost FY 1-5	~Cost FY 6-10	~Cost FY 11-15	~Cost FY 16-20	~Cost FY 21-25	Total ~Cost
Operate the Clear Creek segregation weir to create reproductive isolation between fall-run Chinook salmon and spring-run Chinook salmon.	1	CLC-1.1	SRCS STE	USFWS	1,4	Long-term	$0	$0	$0	$0	$0	$0
Develop a new spawning gravel budget and implement a long-term gravel augmentation plan in Clear Creek, including acquisition of a long-term gravel supply (per CVPIA and RPA action I.1.3 of the 2009 Biological Opinion for the long-term operations of the CVP and SWP (NMFS 2009b).	1	CLC-1.2	SRCS STE	USBR, USFWS	1,5	Long-term	$0	$0	$0	$0	$0	$0
Manage releases from Whiskeytown Dam with instream flow schedules and criteria to provide suitable water temperatures for all life stages, reduce stranding and isolation, protect incubating eggs from being dewatered, and promote habitat quality and availability as described in RPA action I.1.6 of the 2009 Biological Opinion for the long-term operations of the CVP and SWP (NMFS 2009b).	1	CLC-1.3	SRCS STE	USBR, USFWS, Clear Creek Technical Team	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration (years)	~Cost FY 1-5	~Cost FY 6-10	~Cost FY 11-15	~Cost FY 16-20	~Cost FY 21-25	Total ~Cost
Develop water temperature models to improve Clear Creek water temperature management as described in RPA action I.1.5 of the 2009 Biological Opinion for the long-term operations of the CVP and SWP (NMFS 2009b).	1	CLC -1.4	SRCS STE	USBR, USFWS, NMFS	5	Short-term	$0	$0	$0	$0	$0	$0
Adaptively manage Whiskeytown Reservoir releases and water temperatures to evaluate whether anadromy in *O. mykiss* can be increased, without causing adverse impacts to other species.	1	CLC -1.5	STE	USBR, USFWS, NMFS	1	Long-term	$0	$0	$0	$0	$0	$0
Implement channel maintenance flows in Clear Creek called for in the CVP/SWP biological opinion (NMFS 2009b, Action I.1.2).	1	CLC -1.6	SRCS STE	USBR, USFWS, NMFS	1	Long-term	$0	$0	$0	$0	$0	$0
Enhance watershed resiliency in Clear Creek by identifying and implementing projects that would reduce the potential for, and magnitude of wildfires, including projects to restore meadows and forested areas.	2	CLC -2.1	STE	NMFS, USFWS, USBR, CDFW, BLM	1,5	Long-term	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.
Implement the Clear Creek pulse flows called for in the CVP/SWP biological opinion (NMFS 2009b, Action I.1.1), utilizing adaptive management to adjust pulse timing, magnitude, and/or duration, as needed, to be most effective at attracting adult spring-run Chinook salmon.	2	CLC -2.2	SRCS STE	USBR and Clear Creek Technical Team	1,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration (years)	~Cost FY 1-5	~Cost FY 6-10	~Cost FY 11-15	~Cost FY 16-20	~Cost FY 21-25	Total ~Cost
Implement floodplain restoration projects, potentially including the Lower Clear Creek Floodway Rehabilitation Project (Phase 3C).	2	CLC -2.3	SRCS STE	Shasta Resource Conservation District, BLM, Lower Clear Creek Watershed Group, City of Redding	1,5	Part of the Lower Clear Creek Floodway Rehabilitation Project has been completed. Additional projects could occur over the next 10 years.	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.	TBD	$0	$0	$0	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in Clear Creek.	2	CLC -2.4	SRCS STE	NMFS, Corps, USBR, Resource Conservancy, CDFW, DWR, BLM, Landowners, Local governments, NGOs	1,4,5	Short-term	$62,400	$0	$0	$0	$0	$62,400
Develop programs and implement projects for Clear Creek that promote natural river processes, including projects that restore floodplain habitat (e.g., Cloverview project and Paige Bar floodplain lowering project), add riparian habitat and instream cover, and control non-native invasive plant species.	2	CLC -2.5	SRCS STE	Corps, USFWS, DWR, CDFW, BLM, Local agencies, NGOs	1,5	Long-term	<$5,000,000	<$5,000,000	<$5,000,000	<$5,000,000	$0	<$20,000,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration (years)	~Cost FY 1-5	~Cost FY 6-10	~Cost FY 11-15	~Cost FY 16-20	~Cost FY 21-25	Total ~Cost
Develop education and outreach programs to encourage river stewardship in Clear Creek.	2	CLC -2.6	SRCS STE	USFWS, USFS, USEPA, Resource Conservation District, BLM, CDFW, Landowners	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Continue to minimize sources of sediment delivered to Clear Creek from roads and other near stream development by out-sloping roads, constructing diversion prevention dips, replacing under-sized culverts and applying other erosion prevention guidelines.	2	CLC -2.7	SRCS STE	NMFS, USFWS, USFS, CDFW, BLM	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop a long-term operation and maintenance agreement for the segregation weir in Clear Creek.	2	CLC -2.8	SRCS STE	NMFS, USFWS, SWRCB, BLM, CDFW, Local governments	1,5	Short-term	$0	$0	$0	$0	$0	$0
Ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met in Clear Creek for all potential pollutants.	3	CLC -3.1	SRCS STE	SWRCB, CVRWQCBs, Local agriculture groups	1,4	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration (years)	~Cost FY 1-5	~Cost FY 6-10	~Cost FY 11-15	~Cost FY 16-20	~Cost FY 21-25	Total ~Cost
Utilize bio-technical techniques that integrate riparian restoration into bank stabilization projects that may be implemented in the future, instead of conventional rip rap.	3	CLC -3.2	SRCS STE	Corps, USBR, NMFS, USFWS, BLM, CDFW, CBDA	1,5	Long-term	$0	$0	$0	$0	$0	$0
Curtail further development in active Clear Creek floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	3	CLC -3.3	SRCS STE	Corps, NMFS, USFWS, USFS, BLM, CDFW, Local governments	1,4,5	Long-term	$0	$0	$0	$0	$0	$0
Permanently protect Clear Creek riparian and floodplain habitat through easements and/or land acquisition.	3	CLC -3.4	SRCS STE	County, BLM,. CDFW, Tribal, Local owners	1,5	Long-term	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Monitor and evaluate the sport fishing regulations for Clear Creek to ensure they are consistent with the recovery of spring-run Chinook salmon and steelhead. Work with the Fish and Game Commission to modify the regulations as needed.	3	CLC -3.5	SRCS STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration (years)	~Cost FY 1-5	~Cost FY 6-10	~Cost FY 11-15	~Cost FY 16-20	~Cost FY 21-25	Total ~Cost
Negotiate agreements with Federal and State agencies to provide additional instream flows in Clear Creek.	3	CLC-3.6	SRCS STE	NMFS, Corps, USBR, Resource Conservation Districts, CDFW, DWR, Water districts, Landowners, Local governments, NGOs	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water. Cost per unit is $43 - $88/af/year for upstream of Delta water purchases (Appendix D)

5.6.2 Cottonwood/Beegum Creek Recovery Actions

Table 5-7. Cottonwood/Beegum Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY 6-10	~ Cost FY 11-15	~ Cost FY 16-20	~ Cost FY 21-25	Total ~ Cost
Enhance watershed resiliency in Beegum Creek and the greater Cottonwood watershed by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade.	2	CBC-2.1	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group	1,5	Long-term	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.
Develop and implement a spawning gravel augmentation plan in Beegum Creek.	2	CBC-2.2	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group	1,5	Long-term	$50,000 for plan development; gravel augmentation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD
Protect/enhance existing riparian habitat and corridors in Beegum Creek and the greater Cottonwood watershed .	2	CBC-2.3	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group	1	Long-term	$5,000-$50,000 for initial scoping; habitat protection costs TBD	TBD	TBD	TBE	TBD	$5,000-$50,000 for initial scoping; habitat protection costs TBD, based on amount of habitat protected or enhanced. As identified in Appendix D, per unit

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY 6-10	~ Cost FY 11-15	~ Cost FY 16-20	~ Cost FY 21-25	Total ~ Cost
												costs vary depending on whether fencing, planting, irrigation, or invasive weed control are needed.
Apply NMFS gravel mining criteria to all gravel mining projects in Beegum Creek and the greater Cottonwood watershed.	2	CBC-2.4	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group	1,5	Long-term	$0	$0	$0	$0	$0	$0
Integrate riparian habitat restoration into bank protection and other stream side development projects in Beegum Creek and the greater Cottonwood watershed.	2	CBC-2.5	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group	1	Long-term	$0	$0	$0	$0	$0	$0
Implement a non-native plant (e.g. Arundo) eradication plan in Beegum Creek and the greater Cottonwood watershed.	3	CBC-3.1	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY 6-10	~ Cost FY 11-15	~ Cost FY 16-20	~ Cost FY 21-25	Total ~ Cost
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap in Beegum Creek and the greater Cottonwood watershed.	3	CBC-3.2	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group	1	Long-term	$0	$0	$0	$0	$0	$0
Curtail further development in active Beegum and the greater Cottonwood watershed floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	3	CBC-3.3	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group, Local governments	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop education and outreach programs to encourage river stewardship in the Beegum and the greater Cottonwood Creek watershed.	3	CBC-3.4	SRCS STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, CDFW, DWR, Landowners, Cottonwood Creek Watershed Group	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY 6-10	~ Cost FY 11-15	~ Cost FY 16-20	~ Cost FY 21-25	Total ~ Cost
Permanently protect Cottonwood and Beegum Creek riparian habitat through easements and/or land acquisition	3	CBC-3.5	SRCS STE	NMFS, USFWS, USFS, CDFW, DWR, Cottonwood Creek Watershed Group	1,5	Long-term	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the Cottonwood and Beegum watersheds.	3	CBC-3.6	SRCS STE	NMFS, USFWS, USFS, CDFW, Cottonwood Creek Watershed Group	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop cooperative water use agreements with landowners and Federal and State agencies to provide additional instream flows or purchase water rights in Cottonwood Creek.	3	CBC-3.7	SRCS STE	NMFS, Corps, USBR, Resource Conservation Districts, CDFW, DWR, Water districts, Landowners, Local governments, NGOs	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water. Cost per unit is $43 - $88/af/year for upstream of Delta water purchases (Appendix D)
Develop a baseline monitoring program for Beegum Creek to evaluate water quality throughout the watershed to identify areas of concern.	3	CBC-3.8	SRCS STE	NMFS, USFWS, SWRCB, DWR, CDFW, Local governments	1,5	3 Years	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY 6-10	~ Cost FY 11-15	~ Cost FY 16-20	~ Cost FY 21-25	Total ~ Cost
Encourage voluntary landowner participation in Beegum Creek in educational opportunities such as water quality short courses, field demonstrations and distribution of water quality "Fact Sheets".	3	CBC-3.9	SRCS STE	NMFS, USFWS, USEPA, Resource Conservation Districts, CDFW, DWR, Landowners	2	Long-term	$32,260	$32,260	$32,260	$32,260	$0	$129,040
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in Beegum Creek.	3	CBC-3.10	SRCS STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW, Landowners	1,5	Short-term	$62,400	$0	$0	$0	$0	$62,400
Implement projects to minimize predation at weirs, diversion dams, and related structures in Cottonwood/Beegum Creek.	3	CBC-3.11	SRCS STE	NMFS, CDFW, DWR, USFWS, USBR, Corps	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY 6-10	~ Cost FY 11-15	~ Cost FY 16-20	~ Cost FY 21-25	Total ~ Cost
												identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).
Improve instream refuge cover for salmonids in Cottonwood/Beegum Creek to minimize predatory opportunities for striped bass and other non-native predators.	3	CBC-3.12	SRCS STE	NMFS, USFWS, CDFW, DWR	1,3	Short-term	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and placement method. Cost of initial study to address these issues is $5,000-$50,000. See Table H1-2 in Appendix D for cost per unit for various projects.	$0	$0	$0	$0	TBD, based on the # of sites, amount of material needed, type of material, location of source material (onsite vs. imported), and placement method. Cost of initial study to address these issues is $5,000-$50,000. See Table H1-2 in Appendix D for cost per unit for various projects.
Implement projects to increase floodplain habitat availability in Beegum Creek and the greater Cottonwood watershed to improve juvenile rearing habitat	3	CBC-3.13	SRCS STE	NMFS, USFWS, CDFW, DWR	1	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of floodplain habitat restored. $5,000-$50,000 for initial scoping study.

5.6.3 Thomes Creek Recovery Actions

Table 5-8. Thomes Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Conduct a feasibility study on potential channel modifications that would improve upstream migration conditions in Thomes Creek.	3	THC-3.1	STE, SRCS	NMFS, USFWS, CDFW	1,5	5 Years	$50,000-$200,000					$50,000-$200,000
Design and implement a Thomes Creek anadromous fish passage study.	3	THC-3.2	STE, SRCS	NMFS, USFWS, CDFW	1,5	5 Years	$0	$0	$0	$0	$0	$0
Evaluate and improve passage at the Corning Canal siphon and at the two small seasonal push-up diversion dams near Paskenta and Henlyville.	3	THC-3.3	STE, SRCS	NMFS, USFWS, CDFW, DWR, Irrigation districts	1	5 years	$80,000-$382,000/project (CDFW 2004b)					$80,000-$382,000/project (CDFW 2004b)
Flow consolidation through reduction of braided channels in Thomes Creek.	3	THC-3.4	STE, SRCS	NMFS, USFWS, CDFW	1,5	Short-term	$5,000-$50,000 for initial scoping and feasibility; full project cost TBD based on initial study.					$5,000-$50,000 for initial scoping and feasibility; full project cost TBD based on initial study.
Enhance watershed resiliency in Thomes Creek by identifying and implementing projects that	3	THC-3.5	STE, SRCS	NMFS, USFWS, CDFW	1,5	Long-term	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.

would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade.												
Develop and implement a spawning gravel augmentation plan in Thomes Creek.	3	THC-3.6	STE, SRCS	NMFS, USFWS, USBR, CDFW, DWR	1,5	Long-term	$50,000 for plan development; gravel augmentation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD
Conduct West Tehama riparian and floodplain conditions inventory.	3	THC-3.7	STE, SRCS	NMFS, USFWS, Tehama County Resource Conservation Districts, CDFW	1	Complete	$0	$0	$0	$0	$0	$0
Implement projects to increase floodplain habitat availability in Thomes Creek to improve juvenile rearing habitat	3	THC-3.8	STE, SRCS	NMFS, USFWS, CDFW	1,4	Long-term	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.
Re-establish natural channel morphology in Thomes Creek by: (1) applying NMFS gravel mining criteria to all gravel mining projects; (2) integrating natural morphological	3	THC-3.9	STE, SRCS	NMFS, USFWS, Resource Conservation Districts, CDFW, DWR	1,5	Long-term	$0	$0	$0	$0	$0	$0

features and functions into bank protection and other stream side development projects; and (3) implementing non-native plant (e.g. Arundo) eradication plan.												
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the Thomes Creek watershed.	3	THC-3.10	STE, SRCS	NMFS, USFWS, USFS, CDFW, DWR	1,5	Long-term	$0	$0	$0	$0	$0	$0

5.6.4 Stony Creek Recovery Actions

Table 5-9. Stony Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Enhance watershed resiliency in Stony Creek by identifying and implementing projects that would reduce the potential for, and magnitude of a catastrophic wildfire, restore meadows to potentially increase summer flows and reduce local water temperatures, or increase riparian shade.	3	STC-3.1	STE	NMFS, USFWS, CDFW, DWR	1,5	Long-term	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.
Develop and implement a spawning gravel augmentation plan in Stony Creek, which includes habitats above Black Butte Dam after passage is provided.	3	STC-3.2	STE	NMFS, USFWS, USBR, CDFW, DWR	1,5	Long-term	$50,000 for plan development; gravel augmentation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD
Evaluate water releases from Black Butte Dam, water exchanges with the Tehama-Colusa Canal and interim and long term water diversion solutions at RBDD.	3	STC-3.3	STE	Yolo Basin Working Group	1,5	5 years	$0					$0
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the Stony Creek watershed.	3	STC-3.4	STE	NMFS, USFWS, USFS, CDFW	1	Long-term	$0	$0	$0	$0	$0	$0
Develop a baseline monitoring program for Stony Creek to evaluate water quality throughout the	3	STC-3.5	STE	NMFS, USFWS, USFS, CDFW	1	Short-term	$0	$0	$0	$0	$0	$0

watershed to identify areas of concern.												
Encourage voluntary landowner participation in Stony Creek in educational opportunities such as water quality short courses, field demonstrations and distribution of water quality "Fact Sheets".	3	STC-3.6	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, CHS, DWR, CDFW	2	Long-term	$76,140	$76,140	$76,140	$76,140	$0	$304,560
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in Stony Creek.	3	STC-3.7	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, CHS, DWR, CDFW	1	Short-term	$62,400	$0	$0	$0	$0	$62,400
Improve water temperature conditions in Stony Creek by identifying and implementing projects that would increase stream flows and increase shaded riverine habitat.	3	STC-3.8	STE	NMFS, USFWS, CDFW, DWR	1,4	Short-term	TBD	$0	$0	$0	$0	TBD based on the amount of water acquired and/or the amount of shaded habitat restored. Estimate of amount of water to be purchased unavailable. Cost per unit ranges from $43 to $88/af/year for upstream of Delta water purchases (Appendix D). Estimate of amount shaded habitat to be restored unavailable. As identified in Appendix D, per unit costs vary depending on whether fencing, planting, irrigation, or invasive week control are needed. Initial scoping study to determine project details estimated at $5,000-$50,000.

Implement projects to increase floodplain habitat availability in Stony Creek to improve juvenile rearing habitat.	3	STC-3.9	STE	NMFS, USFWS, CDFW, DWR	1,4	Long-term	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.
Install water temperature recorders at select locations in Stony Creek; develop recommendations for minimum instream flow based on temperature needs.	3	SCT-3.10	STE	NMFS, USFWS, CDFW, DWR	1	5 Years	$0					$0
Monitor and evaluate sport-fishing impacts in Stony Creek to ensure that the fishery allows for the recovery of steelhead; modify regulations as necessary.	3	STC-3.11	STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0

5.6.5 Putah Creek Recovery Actions

Table 5-10. Putah Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Conduct an anadromous fish passage feasibility study in Putah Creek that assesses upstream habitat conditions and operational alternatives.	2	PUC-2.1	STE	NMFS, USFWS, USFS, CDFW, DWR, Yolo Basin Working Group	1,5	5 Years	$25,000-$200,000					$25,000-$200,000
Develop a cooperative program to provide water for target flows in Putah Creek from additional Lake Berryessa releases or reductions in water diversions at Solano Diversion Dam and in the creek downstream of the dam.	2	PUC-2.2	STE	NMFS, USFWS, USBR, CDFW, DWR	1,5	Long-term	$0	$0	$0	$0	$0	$0
Implement actions specified by the Putah Creek Council directed at restoring instream and riparian habitat.	2	PUC-2.3	STE	NMFS, USFWS, CDFW, DWR	1	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of habitat restored. As identified in Appendix D, per unit costs vary depending on whether fencing, planting, irrigation, or invasive weed control are needed.
Permanently protect Putah Creek riparian habitat through	2	PUC-2.4	STE	NMFS, USFWS, CDFW, DWR, NRCS	1,5	Long-term	TBD, based on specific easements and	TBD	TBD	TBD	TBD	TBD, based on specific easements and land

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
easements and/or land acquisition							land acquisitions; initial study is expected to cost at least $50,000.					acquisitions; initial study is expected to cost at least $50,000.
Implement projects that improve wastewater and stormwater treatment throughout the Putah Creek watershed.	2	PUC-2.5	STE	NMFS, USFWS, USEPA, SWRCB, DWR, CDFW, Local governments	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water to be treated and whether existing treatment facilities need to be upgraded or new facilities are required.. $5,000-$50,000 for initial evaluation.
Implement projects to maintain and increase floodplain habitat availability in Putah Creek to improve juvenile rearing habitat	2	PUC-2.6	STE	NMFS, USFWS, USBR, CDFW, DWR, Yolo Basin Working Group	1,4	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.
Develop and implement a spawning gravel augmentation plan in Putah Creek.	2	PUC-2.7	STE	NMFS, USFWS, CDFW, DWR	1,5	Long-term	$50,000 for plan development; gravel augmentation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD (based on gravel augmentation costs)
Increase monitoring and enforcement in Putah Creek to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin	2	PUC-2.8	STE	SWRCB, RWQCBs, Local agriculture groups	1,5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Plan) are met throughout the Putah Creek watershed for all potential pollutants (SWRCB 2007).												
Monitor and evaluate sport-fishing impacts in Putah Creek to ensure that the fishery allows for the recovery of steelhead; modify regulations as necessary.	3	PUC-3.1	STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0
Evaluate whether predator control measures can be effective at minimizing predation of juvenile steelhead in Putah Creek; implement measures found to be effective.	3	PUC-3.2	STE	USFWS, NMFS, USBR, CDFW, DWR, Various NGOs	1,3,4	Long-term	TBD	TBD	TBD	TBD	TBD	Cost covered by the cost of SFB-2.5 ($0-$75,000,000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement projects to minimize predation at weirs, diversion dams, and related structures in Putah Creek.	3	PUC-3.3	STE	NMFS, CDFW, DWR, USFWS, USBR, Corps	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).
Improve instream refuge cover for salmonids in Putah Creek to minimize predatory opportunities for striped bass and other non-native	3	PUC-3.4	STE	USFWS, NMFS, USBR, CDFW, DWR	1,3	Long-term	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and	TBD	TBD	TBD	TBD	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and placement

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
predators.							placement method. Initial scoping to address those issues would cost at least $50,000. See Table H1-2 in Appendix D for cost per unit for various projects.					method. Cost of initial study to address these issues is $5,000-$50,000. See Table H1-2 in Appendix D for cost per unit for various projects.
Encourage voluntary landowner participation in Putah Creek in educational opportunities such as water quality short courses, field demonstrations and distribution of water quality “Fact Sheets”.	3	PUC-3.5	STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, DWR, CDFW, Landowners	2	Long-term	$76,140	$76,140	$76,140	$76,140	$0	$304,560
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in Putah Creek.	3	PUC-3.6	STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, DWR, CDFW, Landowners	1,5	Short-term	$62,400	$0	$0	$0	$0	$62,400

5.7 Basalt and Porous Lava Diversity Group Recovery Actions

5.7.1 Cow Creek Recovery Actions

Table 5-11. Cow Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement actions to reduce or eliminate passage impediments in Cow Creek.	2	COC-2.1	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1	5 Years	TBD based on the number and type of impediments. Per unit cost of providing passage at agricultural diversion dams ranges from $30,000 to $1,356,500 (see Appendix D, page 21, table HB-4). Initial evaluation of passage impediments estimated to cost up to $50,000.	$0	$0	$0	$0	TBD based on the number and type of impediments. Per unit cost of providing passage at agricultural diversion dams ranges from $30,000 to $1,356,500 (see Appendix D, page 21, table HB-4). Initial evaluation of passage impediments estimated to cost up to $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Install water temperature recorders at select locations in Cow Creek; develop recommendations for minimum instream flow based on temperature needs.	2	COC-2.2	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1	5 Years	$0	$0	$0	$0	$0	$0
Conduct a Cow Creek diversion mapping study and install screens and ladders at agricultural diversions where necessary.	2	COC-2.3	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1,5	5 Years	$50,000 for mapping study; Per unit cost of providing passage at agricultural diversion dams ranges from $30,000 to $1,356,500 (see Appendix D, page 21, table HB-4)	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).
Develop and apply alternative diversion technologies that eliminate entrainment in Cow Creek.	2	COC-2.4	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD. This action involves development of a new technology such that is impracticable to provide a reasonable estimate of the action's cost.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Enhance watershed resiliency in Cow Creek by identifying and implementing projects that would reduce the potential for, and magnitude of, a catastrophic wildfire, and restore forested areas within the watershed including riparian areas.	2	COC-2.5	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1,5	Long-term	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.
Implement actions specified in the Cow Creek Watershed Management Plan directed at restoring riparian habitat.	2	COC-2.6	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1,4	Long-term	~$235,000 for restoring 10 acres and developing best management practices	$300,000 for monitoring and identification of new restoration sites; if new sites are identified, each is estimated to cost ~$213,000 /10 acres.	$300,000 for monitoring and identification of new restoration sites; if new sites are identified, each is estimated to cost ~$213,000 /10 acres.	$300,000 for monitoring and identification of new restoration sites; if new sites are identified, each is estimated to cost ~$213,000 /10 acres.	$300,000 for monitoring and identification of new restoration sites; if new sites are identified, each is estimated to cost ~$213,000 /10 acres.	>~$1,435,000
Identify stream reaches in Cow Creek that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows.	2	COC-2.7	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1,5	Long-term	$4,217,625	$0	$0	$0	$0	$4,217,625

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Curtail further development in the active Cow Creek floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	2	COC-2.8	STE	NMFS, USFWS, Corps, CDFW, DWR, Local governments	1,5	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement of illegal rip rap applications in Cow Creek.	2	COC-2.9	STE	Corps, SWRCB	1,5	Long-term	$350,000[27]	$350,000	$350,000	$350,000	$350,000	$1,750,000
Develop education and outreach programs to encourage river stewardship in Cow Creek, such as water quality short courses, field demonstrations and distribution of water quality "Fact Sheets".	2	COC-2.10	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000

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[27] Assuming 1 new full time equivalent at $70,000/year, based on the average salary for a California Fish and Game warden as identified on the Bureau of Labor statistics website (http://www.bls.gov/oes/current/oes_ca.htm#19-0000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Cooperatively negotiate long-term agreements with local landowners to maintain and restore riparian communities along lower reaches of Cow Creek (CALFED 2000).	2	COC-2.11	STE	NMFS, USFWS, Corps, USBR, Resource Conservation Districts, CDFW, DWR, Water districts, Landowners, Local governments	1,5	Long-term	$0	$0	$0	$0	$0	$0
Permanently protect Cow Creek riparian habitat through easements and/or land acquisition	2	COC-2.12	STE	NMFS, USFWS, Corps, USBR, Resource Conservation Districts, CDFW, DWR, Water districts, Landowners, Local governments	1,5	Long-term	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Develop and implement a spawning gravel augmentation plan in Cow Creek.	2	COC-2.13	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1,4	Long-term	$50,000 for plan development; gravel augmentation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD (gravel augmentation costs)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Monitor, evaluate, and adaptively manage the Cow Creek rainbow trout stocking program to minimize the potential for adverse impacts to steelhead.	2	COC-2.14	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1,5	3 Years	$0	$0	$0	$0	$0	$0
Implement projects to increase floodplain habitat availability in Cow Creek to improve juvenile rearing habitat	2	COC-2.15	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, Cow Creek Watershed Management Group	1	Long-term	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD, based on amount of floodplain habitat restored; initial study is expected to cost at least $50,000.
Implement projects to increase flows in Cow Creek and tributaries.	2	COC-2.16	STE	NMFS, USFWS, Western Shasta Resource Conservation, CDFW, DWR, SWRCB, Cow Creek Watershed Management Group	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD because the estimate of amount of water to be purchased is unavailable. Cost per unit for upstream of Delta water purchases ranges from $43 to $88/af/year (Appendix D). Cost of an initial study to determine the amount of water needed is at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement the water quality action options described in the Cow Creek Watershed Management Plan.	2	COC-2.17	STE	USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW, Cow Creek Watershed Management Group	1	Long-term	$0	$0	$0	$0	$0	$0
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the Cow Creek watershed.	2	COC-2.18	STE	NMFS, USFWS, USFS, CDFW, Cow Creek Watershed Management Group	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop a baseline monitoring program for Cow Creek to evaluate water quality throughout the watershed to identify areas of concern.	2	COC-2.19	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW, Cow Creek Watershed Management Group	1	2 Years	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in Cow Creek.	2	COC-2.20	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW, Landowners, Cow Creek Watershed Management Group	1,5	Short-term	$62,400	$0	$0	$0	$0	$62,400
Decommission the Kilarc-Cow Creek hydroelectric project (FERC Project No. 606).	2	COC-2.21	STE	PG&E, FERC, NMFS, CDFW, Cow Creek Watershed Management Group	1	Short-term	$0					$0
Monitor and evaluate sport-fishing impacts in Cow Creek to ensure that the fishery allows for the recovery of steelhead; modify regulations as necessary.	2	COC-3.1	STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0

5.7.2 Battle Creek Recovery Actions

Table 5-12. Battle Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Fully fund and implement the Battle Creek Restoration Project through Phase 2	1	BAC-1.1	WRCS, SRCS, STE	USBR, CDFW, NMFS, PG&E, USFWS	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop and implement a winter-run Chinook salmon reintroduction plan to re-colonize historic habitats made accessible by the Battle Creek Restoration Project.	1	BAC-1.2	WRCS	CDFW, USFWS, NMFS, watershed stakeholders, USBR	1,5	15	$1,000,000-$1,333,333	$1,000,000-$1,333,333	$1,000,000-$1,333,333	$0	$0	$3,000,000-$3,999,999
Implement the Battle Creek Salmon and Steelhead Restoration Project Adaptive Management Plan.	1	BAC-1.3	WRCS, SRCS, STE	CDFW, USFWS, NMFS, watershed stakeholders, USBR	1,5	Short-term	$0	$0	$0	$0	$0	$0
Enhance watershed resiliency in Battle Creek by developing a strategy to identify and prioritize vegetation and fuels treatments that would reduce the potential extent and/or the magnitude of high severity wildfires.	1	BAC-1.4	WRCS, SRCS, STE	USBR, NMFS, USFWS, CDFW	1,5	Long-term	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Ensure that timber cutting operations on private lands in the Battle Creek watershed follow the State Forest Practice rules.	1	BAC-1.5	WRCS, SRCS, STE	USBR, NMFS, USFWS, FERC, CDFW, SWRCB, SPI	1,5	Long-term	$0	$0	$0	$0	$0	$0
Implement a water quality monitoring program throughout the Battle Creek watershed to identify areas of concern. The program should monitor for sediment loading and include detection of chemical/nutrient inputs from illegal plant cultivation operations.	1	BAC-1.6	WRCS, SRCS, STE	USBR, NMFS, USFWS, FERC, CDFW, SWRCB	1,5	5	$0	$0	$0	$0	$0	$0
Develop an Adaptive Management Plan for Coleman National Fish Hatchery and continue to integrate hatchery operations with Battle Creek Salmon and Steelhead Restoration Project activities.	1	BAC-1.7	WRCS, SRCS, STE	CDFW, USFWS, NMFS, watershed stakeholders, USBR	1,4,5	Short-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Evaluate the scientific merits of moving Coleman National Fish Hatchery operations for the production of steelhead and late-fall Chinook salmon to minimize adverse impacts to listed species. If warranted, then follow with an assessment of the feasibility of moving the programs.	1	BAC-1.8	WRCS, SRCS, STE	CDFW, USFWS, NMFS, watershed stakeholders, USBR	1,3,5	Short-term evaluation; long-term implementation	TBD	TBD	TBD	TBD	TBD	TBD; The cost of the evaluation and, if necessary, the feasibility assessment will be identified by the Coleman Hatchery Coordination Team that will be formed according to the recommendation from the Hatchery Scientific Review Group.
Finalize the Biological Opinion for the artificial propagation at Coleman National Fish Hatchery.	1	BAC-1.9	WRCS, SRCS, STE	FWS, NMFS	1,5	1 year	$0	$0	$0	$0	$0	$0
Evaluate the need to upgrade PG&E facilities in order to reduce the potential for outages and harmful flow fluctuations. If outages and flow fluctuations are important stressors after completion of the Battle Creek Salmon and Steelhead Restoration	1	BAC-1.10	WRCS, SRCS, STE	Corps, USFWS, NMFS, CDFW, PG&E	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD based on whether or not facilities need to be upgraded. Evaluation of facilities estimated to cost up to $100,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Project, then PG&E facilities should be upgraded.												
Develop and utilize the Battle Creek Fisheries Management Plan.	1	BAC-1.11	WRCS, SRCS, STE	CDFW, USFWS, NMFS	1,5	Short-term	$0	$0	$0	$0	$0	$0
Improve fish passage at natural (rock or wood) fish barriers in the watershed including the ones immediately upstream and downstream of Eagle Canyon, and at the mouth of Digger Creek.	1	BAC-1.12	WRCS, SRCS, STE	CDFW, USFWS, NMFS	1,5	Short-term	$500,000					$500,000
Develop and apply alternative water diversion technologies that eliminate entrainment in Battle Creek.	2	BAC-2.1	WRCS, SRCS, STE	FWS, CDFW	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD. This action involves development of a new technology such that is impracticable to provide a reasonable estimate of the action's cost.
Implement a study designed to evaluate the impact of predation on spring-run Chinook salmon and steelhead in	2	BAC-2.2	WRCS, SRCS, STE	FWS, CDFW, NMFS	1,3,5	Long-term						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Battle Creek. If the study suggests that predation is an important stressor in Battle Creek, then implement projects to minimize predation, potentially including predator removal and/or harvest management.												
Implement projects to minimize predation at weirs, diversion dams, and related structures in Battle Creek.	2	BAC-2.3	WRCS, SRCS, STE	NMFS, CDFW, DWR, USFWS, USBR, Corps, PG&E	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												site will cost about $38,000 annually (BDCP 2013).
The Corps, DWR, CDFW, BLM, USFWS, NMFS, private land owners, and Resource Conservation Districts should continue to focus on retaining, restoring and creating continuous riparian corridors within their jurisdictions in Battle Creek in order to improve natural river function and provide predator refuge habitat.	2	BAC-2.4	WRCS, SRCS, STE	DWR, BLM, TNC, USFWS, CDFW	1,5	Long-term	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$150,000 -$675000
Increase monitoring and enforcement in order to eliminate/minimize illegal plant cultivation operations and anadromous fish poaching in the Battle Creek watershed.	2	BAC-2.5	WRCS, SRCS, STE	CDFW	1,5	Long-term						Cost is covered under action # COC-2.9
Permanently protect Battle Creek riparian habitat through	2	BAC-2.6	WRCS, SRCS, STE	DWR, BLM, TNC, USFWS, CDFW	1,5	Long-term	TBD, based on specific easements and land	TBD	TBD	TBD	TBD	TBD, based on specific easements and land acquisitions; initial

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
easements and/or land acquisition.							acquisitions; initial study is expected to cost at least $50,000.					study is expected to cost at least $50,000.
Ensure through the FERC process and monitoring that the hydroelectric project at Lassen Lodge on the South Fork of Battle Creek avoids or minimizes any adverse impacts to listed anadromous salmonids.	2	BAC-2.7	WRCS, SRCS, STE	FERC, USFS, NMFS, CDFW	1,3,5	Short-term	$0	$0	$0	$0	$0	$0
Utilize bio-technical techniques for river bank stabilization instead of conventional rip rap in Battle Creek.	3	BAC-3.1	WRCS, SRCS, STE	Corps, USFWS	1,5	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement to minimize illegal streambank alterations in Battle Creek.	3	BAC-3.2	WRCS, SRCS, STE	CDFW, Corps, USFWS	1,5	Long-term						Cost is covered under action # COC-2.9

5.8 Northern Sierra Nevada Diversity Group Recovery Actions

5.8.1 Antelope Creek Recovery Actions

Table 5-13. Antelope Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Restore instream flows during upstream and downstream migration periods through water exchange agreements and provide alternative water supplies to Edwards Ranch and Los Molinos Mutual Water Company in exchange for instream fish flows.	1	ANC-1.1	SRCS, STE	NMFS, USFWS, CDFW, Edwards Ranch, Los Molinos Mutual Water Company	1	Long-term	$0	$0	$0	$0	$0	$0
Restore connectivity of the migration corridor during upstream and downstream migration periods by implementing Edwards and Penryn fish passage and entrainment improvement projects and identify and	1	ANC-1.2	SRCS, STE	CDFW, Edwards Ranch	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
construct a defined stream channel for upstream and downstream fish migration												
Create and restore side channel habitats to increase the quantity and quality of off-channel rearing (and spawning) areas in Antelope Creek.	2	ANC-2.1	SRCS, STE	NMFS, CDFW	1	Short-term	TBD based on the amount of side channel habitat restoration. Unit cost is $20,000 to $300,000/acre (Appendix D). $5,000-$50,000 for initial evaluation.	TBD based on the amount of side channel habitat restoration. Unit cost is $20,000 to $300,000/acre (Appendix D). $5,000-$50,000 for initial evaluation.	TBD based on the amount of side channel habitat restoration. Unit cost is $20,000 to $300,000/acre (Appendix D). $5,000-$50,000 for initial evaluation.	TBD based on the amount of side channel habitat restoration. Unit cost is $20,000 to $300,000/acre (Appendix D). $5,000-$50,000 for initial evaluation.	TBD based on the amount of side channel habitat restoration. Unit cost is $20,000 to $300,000/acre (Appendix D). $5,000-$50,000 for initial evaluation.	TBD based on the amount of side channel habitat restoration. Unit cost is $20,000 to $300,000/acre (Appendix D). $5,000-$50,000 for initial evaluation.
Federal, State, and local agencies should use their authorities to develop and implement programs and projects that focus on retaining, restoring and creating riparian and floodplain habitat in Antelope Creek.	2	ANC-2.2	SRCS, STE	NMFS, USFWS, CDFW, DWR, Irrigation districts	1	Short-term	TBD based on type and amount of habitat restored; initial study is expected to cost at least $50,000.	TBD	$0	$0	$0	TBD based on type and amount of habitat restored; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Improve passage conditions at Paynes crossing to allow upstream passage during low flows.	2	ANC-2.3	SRCS, STE	NMFS, USFWS, USFS, CDFW, DWR	1	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement of illegal rip rap applications in Antelope Creek.	2	ANC-2.4	SRCS, STE	Corps, SWRCB	1	Long-term						Cost is covered under action # COC-2.9
Develop education and outreach programs to encourage river stewardship in Antelope Creek.	2	ANC-2.5	SRCS, STE	NMFS, USFWS, USFS, CDFW, DWR, NGOs	5	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Evaluate the quality and quantity of spawning habitat in Antelope Creek and rehabilitate spawning habitat as needed.	2	ANC-2.6	SRCS, STE	NMFS, USFWS, CDFW, DWR	1	Long-term	$50,000 for plan development; rehabilitation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD
Develop and implement TMDL's for all pollutants in Antelope Creek	2	ANC-2.7	SRCS, STE	NMFS, USFWS, USFS, CDFW	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Increase monitoring and enforcement in the Antelope Creek watershed to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants.	2	ANC-2.8	SRCS, STE	SWRCB, RWQCBs, Local agriculture groups	1	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)
Develop a baseline monitoring program in Antelope Creek to evaluate water quality throughout the watershed to identify areas of concern.	2	ANC-2.9	SRCS, STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW	1	3 Years	$0	$0	$0	$0	$0	$0
Enhance watershed resiliency in Antelope Creek by developing a strategy to identify and prioritize vegetation and fuels treatments that would reduce the potential extent and/or the	2	ANC-2.10	SRCS, STE	NMFS, USFWS, USFS, CDFW	1	Long-term	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
magnitude of high severity wildfires.												
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the Antelope Creek watershed.	2	ANC-2.11	SRCS, STE	NMFS, USFWS, USFS, CDFW	1	Long-term	$0	$0	$0	$0	$0	$0
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap in Antelope Creek.	2	ANC-2.12	SRCS, STE	NMFS, USFWS, Corps, USBR, DWR, CDFW, CBDA	1	Long-term	$0	$0	$0	$0	$0	$0
Implement projects that cooperatively work with landowners to modify existing diversions in Antelope Creek so that fish do not become entrained in agricultural fields.	2	ANC-2.13	SRCS, STE	NMFS, USFWS, CDFW, DWR, Landowners, Irrigation districts	1,5	Short-term	TBD	TBD	$0	$0	$0	TBD, based on the type of diversion modification. If a fish screen is the solution, the cost will generally range from $2 to $10 thousand per cfs (Appendix D). $5,000-$50,000 for initial evaluation.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Monitor and evaluate the sport fishing regulations for Antelope Creek to ensure they are consistent with the recovery of spring-run Chinook salmon and steelhead, and work with the Fish and Game Commission to modify the regulations as needed.	2	ANC-3.1	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	2	Long-term	$0	$0	$0	$0	$0	$0

5.8.2 Mill Creek Recovery Actions

Table 5-14. Mill Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Modify Ward, Upper, and Cemetery Ditch Siphon diversions and associated structures in Mill Creek in order to minimize entrainment and provide unimpeded passage for adult and juvenile Chinook salmon and steelhead. The modifications should meet the fish passage design criteria developed by NMFS as well as the criteria developed by CDFW.	1	MIC-1.1	SRCS, STE	NMFS, CDFW, Los Molinos Mutual Water Company, DWR, USFWS, Mill Creek Conservancy, TNC	1,5	Short-term	$2,672,672	$0	$0	$0	$0	$2,672,672
Analyze previous Mill Creek flow studies (i.e., Alley 1996; Harvey-Arrison 2009) to identify the flow regime in the flow control reach (i.e., downstream of Upper Diversion to the confluence with the Sacramento River) that best supports the life stages of spring-run Chinook salmon and steelhead that occur in that reach; conduct an additional flow study if necessary.	1	MIC-1.2	SRCS, STE	NMFS, CDFW, Los Molinos Mutual Water Company, DWR, USFWS, Mill Creek Conservancy, TNC, NFWF	1,5	Short-term	$200,000	$0	$0	$0	$0	$200,000
Develop and implement instream flow agreements with Mill Creek diverters designed to provide flows that best support the life stages of spring-run Chinook salmon and steelhead that occur in the flow control reach (i.e., downstream of Upper Diversion to the confluence with the Sacramento River).	1	MIC-1.3	SRCS, STE	NMFS, CDFW, Los Molinos Mutual Water Company, DWR, USFWS, Mill Creek Conservancy, TNC, NFWF	1,5		TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water. Cost per unit is $43 - $88/af/year for upstream of Delta water purchases (Appendix D)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
The agreements can include approaches such as groundwater exchange, water leases, acquiring water rights, and other water management options.												
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the upper Mill Creek watershed. On National Forest Service (NFS) lands, this action should follow the prioritization criteria and strategies identified in the Long-term Strategy for Anadromous Fish-producing Watersheds in the Lassen National Forest (USFS 2001).	1	MIC-1.4	SRCS, STE	USFS, NMFS, USFWS, CDFW, DWR, Mill Creek Conservancy, TNC	1,4,5	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement in order to eliminate/minimize illegal plant cultivation operations and anadromous fish poaching in the Mill Creek watershed.	1	MIC-1.5	SRCS, STE	NMFS, CDFW, SWRCB	2,4							Cost is covered under action # COC-2.9
Conduct real time flow and water temperature monitoring in Mill Creek in order to inform real time management decisions.	1	MIC-1.6	SRCS, STE	CDFW, USGS, DWR, Los Molinos Mutual Water Company	1,5		$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Build partnerships with land owners and/or permittees in the Mill Creek watershed to develop grazing strategies that promote meadow restoration, protect and improve streamside vegetation, and minimize bank disturbance.	2	MIC-2.1	SRCS, STE	NMFS, USFWS, CDFW, DWR, Mill Creek Conservancy, TNC	1,5		$47,520	$0	$0	$0	$0	$47,520
Implement a water quality monitoring program throughout the Mill Creek watershed to identify areas of concern.	2	MIC-2.2	SRCS, STE	NMFS, USFWS, CDFW, DWR, SWRCB, USEPA	1,4,5	Long-term	$0	$0	$0	$0	$0	$0
Develop education and outreach programs to encourage river stewardship in Mill Creek. Collaborate with the Mill Creek Watershed Conservancy in watershed management activities and any other public education events related to river stewardship.	2	MIC-2.3	SRCS, STE	CDFW, Mill Creek Conservancy, TNC, USFWS, NMFS, Los Molinos Mutual Water Company	2		$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Ensure that timber cutting operations in the Mill Creek watershed follow the State Forest Practice rules.	2	MIC-2.4	SRCS, STE	CDFW, CalFire, Board of Forestry, NMFS, USFWS, USFS	1,5		$0	$0	$0	$0	$0	$0
Enhance watershed resiliency in Mill Creek by developing a strategy to identify and prioritize vegetation and fuels treatments that would reduce the potential extent and/or the magnitude of high severity wildfires.	2	MIC-2.5	SRCS, STE	USFS, CalFire, NMFS, USFWS, , CDFW, Mill Creek Conservancy	1,5	Long-term	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Investigate whether there are areas in the Mill Creek valley reach where it would be feasible to implement floodplain restoration projects in order to improve habitat conditions for juvenile rearing. If there are floodplain restoration opportunities, those projects should be prioritized and implemented as funding becomes available.	2	MIC-2.6	SRCS, STE	NMFS, USFWS, CDFW, DWR, Mill Creek Conservancy, TNC	1,5	Short-term	$50,000 for investigation; cost of floodplain restoration TBD based on amount of habitat to be restored. Per unit cost of floodplain habitat restoration is $5,000 to $80,000/acre (Appendix D Table HI-4)	TBD	$0	$0	$0	$50,000-TBD
Monitor and evaluate the sport fishing regulations for Mill Creek to ensure they are consistent with the recovery of spring-run Chinook salmon and steelhead, and modify the regulations as needed. Establish and enforce hook size restrictions intended to allow trout fishing, but minimize angling impacts on salmon.	2	MIC-2.7	SRCS, STE	CDFW, Fish and Game Commission, NMFS	2,4		$0	$0	$0	$0	$0	$0
Identify stream reaches in Mill Creek that have been most altered by anthropogenic factors and develop restoration actions that restore natural river processes.	2	MIC-2.8	SRCS, STE	NMFS, USFWS, CDFW, DWR, Mill Creek Conservancy, TNC	1,5		$4,217,625	$0	$0	$0	$0	$4,217,625

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Curtail further development in the active Mill Creek floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	2	MIC-2.9	SRCS, STE	Local governments, NMFS, USFWS, CDFW, DWR, Mill Creek Conservancy, TNC	1,4	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement to minimize illegal streambank alterations in Mill Creek.	2	MIC-2.10	SRCS, STE	CDFW, NMFS, Corps, SWRCB	1,5	Long-term						Cost is covered under action # COC-2.9
Permanently protect riparian habitat along Mill Creek through easements and/or land acquisition.	2	MIC-2.11	SRCS, STE	CDFW, USFWS, NMFS, Mill Creek Conservancy, TNC	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Develop and implement actions to remove feral cows in the Black Rock area of Mill Creek.	2	MIC-2.12	SRCS, STE	CDFW, USFWS, NMFS, Mill Creek Conservancy, TNC	1,5	Short-term	TBD	$0	$0	$0	$0	TBD, based on number of cows. Cost per cow removed is $150 (Bratcher 2013).

5.8.3 Deer Creek Recovery Actions

Table 5-15. Deer Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement instream flow agreements with the Deer Creek Irrigation District and the Stanford-Vina Ranch Irrigation Company designed to provide flows that best support all life stages of spring-run Chinook salmon and steelhead. The agreements can include approaches such as groundwater exchange, water leases, and other water management options.	1	DEC-1.1	SRCS, STE	Corps, SWRCB, DCID, SVRIC	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water. Cost per unit is $43 - $88/af/year for upstream of Delta water purchases (Appendix D)
Modify the Cone-Kimball Diversion, Stanford-Vina Dam, and the Deer Creek Irrigation District Dam in order to provide unimpeded passage for adult and juvenile Chinook salmon and steelhead. The modifications should meet the fish passage design criteria developed by NMFS and CDFW.	1	DEC-1.2	SRCS, STE	NMFS, USFWS, USFS, CDFW, DWR, NGOs	1,5	Short-term	$10,925,000	$12,629,300	$0	$0	$0	$23,554,300

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
In coordination with technical advisors from the natural resource agencies, implement the Deer Creek Flood Improvement Project, and other projects to increase Deer Creek floodplain habitat availability.	1	DEC-1.3	SRCS, STE	NMFS, USFWS, CDFW, DWR	1,4	Short-term	$1,860,000	$0	$0	$0	$0	$1,860,000
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the upper Deer Creek watershed. On National Forest Service lands, this action should follow the prioritization criteria and strategies identified in the Long-term Strategy for Anadromous Fish-producing Watersheds in the Lassen National Forest (USFS 2001).	1	DEC-1.4	SRCS, STE	NMFS, USFWS, USFS, CDFW	1,4	Long-term	$0	$0	$0	$0	$0	$0
Conduct an instream flow study to identify the flow regime in lower Deer Creek that best supports migration and rearing of spring-run Chinook salmon and steelhead.	1	DEC-1.5	SRCS, STE	CDFW, Deer Creek Irrigation Company, Stanford-Vina, SWRCB, DWR, Deer Creek Watershed Conservancy	1,5	Long-term	$1,600,000	$0	$0	$0	$0	$1,600,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Based on instream flow study results, develop an adaptive management strategy to provide a flow regime in the lower watershed that best supports spring-run Chinook salmon and steelhead during fish migration and rearing periods.	1	DEC-1.6	SRCS, STE	CDFW, Deer Creek Irrigation Company, Stanford-Vina, SWRCB, DWR, Deer Creek Watershed Conservancy	1,5	Long-term	$0	$0	$0	$0	$0	$0
Conduct real time flow and water temperature monitoring in Deer Creek in order to inform real time management decisions.	1	DEC-1.7	SRCS, STE	NMFS, USFWS, USGS, CDFW, DWR	1,5	Long-term	$0	$0	$0	$0	$0	$0
Implement a Deer Creek monitoring program to identify the abundance and the temporal and spatial distributions of immigrating and holding spring-run Chinook salmon and steelhead. These data would help ensure that suitable flows and water temperatures are being provided when and where the fish are immigrating and holding. Additionally, the data would help estimate the abundance of both species.	1	DEC-1.8	SRCS, STE	CDFW, SPI	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Increase monitoring and enforcement in order to eliminate/minimize illegal plant cultivation operations and anadromous fish poaching in the Deer Creek watershed.	1	DEC-1.9	SRCS, STE	CDFW, Deer Creek Irrigation Company, Stanford-Vina, Deer Creek Watershed Conservancy	1,4,5	Long-term						Cost is covered under action # COC-2.9
Study feasibility of consolidating diversion points (e.g., Stanford Vina and Cone-Kimball diversions) to minimize the number of diversions on Deer Creek. Based on this study, consolidate diversions where feasible.	2	DEC-2.1	SRCS, STE	NMFS, CDFW, Deer Creek Watershed Conservancy, Deer Creek Irrigation Company, Stanford-Vina, SWRCB, DWR	1,5	10 Years	$50,000	$750,000	$0	$0	$0	$800,000
Assess the feasibility and need for modifying the lower Deer Creek falls fish ladder, to improve its function for allowing upstream passage to the upper six miles of anadromous habitat. Implement modifications as needed.	2	DEC-2.2	SRCS, STE	NMFS, USFWS, USFS, CDFW	1,5	5 Years	$0	$0	$0	$0	$0	$0
Enhance watershed resiliency in Deer Creek by developing and implementing a strategy to identify and prioritize vegetation and fuels treatments that would reduce the potential extent and/or the magnitude of high severity wildfires.	2	DEC-2.3	SRCS, STE	SWRCB, RWQCBs, Local agriculture groups	1,4,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount and type of habitat restored; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Build partnerships with land owners and/or permittees in the Deer Creek watershed to develop grazing strategies that promote meadow restoration, protect and improve streamside vegetation, and minimize bank disturbance.	2	DEC-2.4	SRCS, STE	NMFS, CDFW, Deer Creek Watershed Conservancy, USFWS	1,5	Long-term	$47,520	$0	$0	$0	$0	$47,520
Maintain an up-to-date Highway 32 Contingency Spill Plan to ensure immediate emergency response strategy and continue to develop alternatives to reduce the potential for hazardous material spills along Deer Creek.	2	DEC-2.5	SRCS, STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW	4,5	Long-term	$0	$0	$0	$0	$0	$0
Work with California Department of Transportation (Caltrans) to ensure that proposed changes to the existing Highway 32 road alignment would not contribute to potentially unacceptable effects to anadromous fish and/or their habitat (e.g. increases in fine grained sediment, increased risk of hazardous spills).	2	DEC-2.6	SRCS, STE	NMFS, USFWS, USFS, CDFW	4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop education and outreach programs to encourage river stewardship in Deer Creek. Continue educational outreach and support and assist Deer Creek Watershed Conservancy (DCWC) in watershed management activities (AFRP Website 2005).	2	DEC-2.7	SRCS, STE	NMFS, USFWS, USFS, CDFW	2,5	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Continue implementing a water quality monitoring program throughout the Deer Creek watershed to identify areas of concern. The monitoring program should include detection of chemical/nutrient inputs from illegal plant cultivation operations.	2	DEC-2.8	SRCS, STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW	1,4	2 Years	$0	$0	$0	$0	$0	$0
To recruit and provide a continuous supply of spawning gravels into Deer Creek, re-design the Highway 32 culvert crossing at the South Fork of Calf Creek to allow for unimpeded bedload transport.	2	DEC-2.9	SRCS, STE	Caltrans, NMFS, CDFW, Deer Creek Watershed Conservancy, Deer Creek Irrigation Company, Stanford-Vina	1,5	Long-term	$50,000	$0	$0	$0	$0	$50,000
Ensure that timber cutting operations on private lands in the Deer Creek watershed follow the State Forest Practice rules.	2	DEC-2.10	SRCS, STE	Board of Forestry, Deer Creek Watershed Conservancy, SPI, Collins Pine Timber Co	1,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Monitor and evaluate the sport fishing regulations for Deer Creek to ensure they are consistent with the recovery of spring-run Chinook salmon and steelhead, and work with the Fish and Game Commission to modify the regulations as needed. Work with CDFW and the Fish and Game Commission to establish and enforce hook size restrictions intended to allow trout fishing, but minimize angling impacts on salmon.	2	DEC-2.11	SRCS, STE	CDFW, NMFS, Deer Creek Watershed Conservancy	2,4	Long-term	$0	$0	$0	$0	$0	$0
Identify stream reaches in Deer Creek that have been most altered by anthropogenic factors and promote development of actions that contribute to the restoration of riparian vegetation and natural river processes.	2	DEC-2.12	SRCS, STE	CDFW, NMFS, Deer Creek Watershed Conservancy, SPI, Collins Pine Timber Co	1,5	Long-term	$0	$0	$0	$0	$0	$0
Curtail further development in the active Deer Creek floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	2	DEC-2.13	SRCS, STE	Local governments, Corps, NMFS, CDFW, grazing interests, Deer Creek Watershed Conservancy	1,4	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Increase monitoring and enforcement to minimize illegal streambank alterations in Deer Creek.	2	DEC-2.14	SRCS, STE	CDFW, Corps, SWRCG, NMFS	1,4,5	Long-term						Cost is covered under action # COC-2.9
Permanently protect Deer Creek riparian habitat through easements and/or land acquisition.	2	DEC-2.15	STE	NMFS, USFWS, DWR, CDFW	1,5	Long-term	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Monitor, evaluate, and adaptively manage the upper Deer Creek rainbow trout stocking program to minimize the potential for adverse impacts to spring-run Chinook salmon or steelhead.	2	DEC-2.16	SRCS, STE	CDFW, NMFS	4,5	5 Years	$0	$0	$0	$0	$0	$0
Evaluate the scientific merits of improving the Upper Falls fish ladder on Deer Creek to allow steelhead access to the upper watershed. The existing ladder will remain closed and improvements to it will not be undertaken unless Deer Creek habitat modeling verifies that: (1) steelhead spawning and rearing habitats below the Upper Falls are limiting steelhead recovery; and (2)	2	DEC-2.17	SRCS, STE	CDFW, NMFS, USBR (Shasta Mitigation)	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
spawning and rearing habitats above the Upper Falls are suitable and necessary to recover the Deer Creek steelhead population.												
Ensure that through the FERC relicensing process for the Fire Mountain Lodge Hydroelectric Project, detailed mitigation and design criteria are implemented to reduce the potential for impacts into downstream anadromous habitat.	3	DEC-3.1	SRCS, STE	FERC, NMFS, USFS	1,5	Long-term	$0	$0	$0	$0	$0	$0

5.8.4 Big Chico Creek Recovery Actions

Table 5-16. Big Chico Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement fish passage improvement projects at the recreational pools in Bidwell Park.	1	BCC-1.1	SRCS, STE	NMFS, USFWS, CDFW, DWR, Big Chico Watershed Alliance	1	5 Years	$500,000	$0	$0	$0	$0	$500,000
Re-establish spring-run Chinook salmon and steelhead passage at low and moderate flows through Iron Canyon.	1	BCC-1.2	SRCS, STE	City of Chico, USFWS, CDFW, NMFS, Big Chico Creek Ecological Reserve, Chico State University, Butte County, Sierra Nevada Conservancy	1	5 years	$1,000,000					$1,000,000
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the Big Chico Creek watershed.	2	BCC-2.1	SRCS, STE	NMFS, USFWS, USFS, CDFW	1,5	Long-term	$0	$0	$0	$0	$0	$0
Enhance watershed resiliency in Big Chico Creek by identifying and implementing projects that would reduce the potential for, and magnitude of, a catastrophic wildfire, and restore forested areas within the watershed including riparian areas.	2	BCC-2.2	SRCS, STE	NMFS, USFWS, CDFW, DWR, Big Chico Watershed Alliance	1,5	Long-term	TBD based on amount and type of habitat restored; initial study is expected to cost at least	TBD	TBD	TBE	TBD	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
							$50,000.					
Implement projects to increase Big Chico Creek floodplain habitat availability to improve habitat conditions for juvenile rearing	2	BCC-2.3	SRCS, STE	NMFS, USFWS, CDFW, DWR, Big Chico Watershed Alliance	1	Long-term	TBD based on amount of habitat restored; initial study is expected to cost at least $50,000. Per unit cost is $5,000 to $80,000/acre (Appendix D Table HI-4)	TBD	TBD	TBD	TBD	TBD based on amount of habitat restored; initial study is expected to cost at least $50,000. Per unit cost is $5,000 to $80,000/acre (Appendix D Table HI-4)
Identify stream reaches in Big Chico Creek that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows.	2	BCC-2.4	SRCS, STE	NMFS, USFWS, CDFW, DWR, Big Chico Watershed Alliance	1,5	5 Years	$4,217,625	$0	$0	$0	$0	$4,217,625
Curtail further development in the active Big Chico Creek floodplains through zoning restrictions, county master plans, HCPs, and other Federal, State, and county planning and regulatory processes.	2	BCC-2.5	SRCS, STE	NMFS, USFWS, USFS, Corps, CDFW, DWR, Local governments	1,3, 5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Increase monitoring and enforcement of illegal rip rap applications in Big Chico Creek.	2	BCC-2.6	SRCS, STE	Corps, SWRCB	1,5	Long-term						Cost is covered under action # COC-2.9
Develop education and outreach programs to encourage river stewardship in Big Chico Creek.	2	BCC-2.7	SRCS, STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, Landowners, Local Schools	1	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Increase monitoring and enforcement in Big Chico Creek to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants (SWRCB 2007).	2	BCC-2.8	SRCS, STE	SWRCB, RWQCBs, Local agriculture groups	1,5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)
Develop a baseline monitoring program to evaluate water quality throughout the watershed to identify areas of concern.	2	BCC-2.9	SRCS, STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, CDFW	1,5	3 Years	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts.	2	BCC-2.10	SRCS, STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, CDFW, DWR, Landowners	1,5	Long-term	$62,400	$0	$0	$0	$0	$62,400

5.8.5 Butte Creek Recovery Actions

Table 5-17. Butte Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Identify and establish minimum instream flow requirements for Butte Creek that support all life stages of spring-run Chinook salmon and steelhead.	1	BUC-1.1	SRCS, STE	SWRCB, RWQCBs, Local agriculture groups	1	Long-term	$0	$0	$0	$0	$0	$0
Install and maintain real-time flow and water temperature monitoring gages in Butte Creek in order to help make real-time management decisions.	1	BUC-1.2	SRCS, STE	CDFW, DWR, USFWS, NMFS, SWRCB	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop an entrainment monitoring program in Butte Creek to determine the level of take at individual diversions. Prioritize diversions based on this monitoring and screen those	1	BUC-1.3	SRCS, STE	NMFS, USFWS, CDFW, DWR	1,3,5	5 years	$100,000 for monitoring program; costs of screens for Butte Creek TBD	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
that are determined to have substantial impacts.												
Implement projects that consolidate and screen existing diversions in Butte Creek where feasible.	1	BUC-1.4	SRCS, STE	NMFS, USBR, CDFW, DWR, Irrigation districts, Water districts	1,3,5	Long-term	$50,000	$750,000	$0	$0	$0	$800,000
Develop information to better understand the interaction between surface water and groundwater in the Butte Creek watershed in order to evaluate the potential impacts of water management options (e.g., groundwater sales; conjunctive use) in the watershed on the Butte Creek flow regime.	1	BUC-1.5	SRCS, STE	SWRCB, CDFW, DWR Irrigation districts	4,5	Short-term	$0	$0				$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement projects that improve water temperature management in Butte Creek, including facility modifications to the DeSabla-Centerville Hydroelectric Project.	1	BUC-1.6	SRCS, STE	PG&E, NMFS, CDFW, FERC, SWRCB	1	Short-term	TBD. NMFS is in the process of obtaining the cost from PG&E.					TBD. NMFS is in the process of obtaining the cost from PG&E.
Improve the segregation of Butte Creek spring-run and fall-run Chinook salmon during spawning by development and installation of a more robust separation device or removable weir at or near the Parrott-Phelan diversion dam. The segregation device should allow adult steelhead passage.	1	BUC-1.7	SRCS	CDFW, NMFS, USFWS, PG&E	1	Short-term	< $500,0000					<$500,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement programs and measures designed to control non-native predatory fish in Butte Sink and the Sutter Bypass, including harvest management techniques and programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).	2	BUC-2.1	SRCS, STE	NMFS, USFWS, CDFW, DWR	2,3	Long-term	TBD	TBD	TBD	TBD	TBD	Cost covered by the cost of SFB-2.5 ($0-$75,000,000).
Increase instream cover in Butte Creek in order to minimize predatory opportunities for striped bass and other non-native predators on anadromous salmonids.	2	BUC-2.2	SRCS, STE	Corps, USFWS, NMFS, CDFW	1,3	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on the # of sites, amount of material needed, type of material, location of source material (onsite vs. imported), and placement method. Cost of initial study to address these issues is $5,000-$50,000. See Table H1-2 in Appendix D for cost per unit for various projects
Implement flow ramping protocols in Butte Creek to protect all life	2	BUC-2.3	SRCS, STE	NMFS, USFWS, CDFW, DWR, PG&E, FERC	1,4	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in the FERC licensing process

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
stages of spring-run Chinook salmon and steelhead.												
Develop and implement a strategy that prioritizes projects with the intent of promoting Butte Creek watershed resiliency and reducing the potential for wildfires.	2	BUC-2.4	SRCS, STE	NMFS, USFWS, CDFW, Butte Creek Watershed Conservancy, PG&E	1,4	Long-term	$0	$0	$0	$0	$0	$0
Identify stream reaches in Butte Creek that have been most altered by anthropogenic factors and develop and implement actions that restore natural river processes; conduct associated public outreach projects. One specific issue that should be addressed by this action is the number of temporary passage	2	BUC-2.5	SRCS, STE	NMFS, USFWS, CDFW, DWR	1	Long-term	$4,217,625	$0	$0	$0	$0	$4,217,625

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
impediments installed to create swimming holes in Butte Creek near Chico.												
Develop and implement programs and projects that focus on maintaining and restoring riparian corridors within the Butte Creek watershed.	2	BUC-2.6	SRCS, STE	NMFS, USFWS, USFS, CDFW, DWR, Local governments	1,4	Long-term	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$150,000 -$675000
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap in Butte Creek.	2	BUC-2.7	SRCS, STE	Corps, USBR, NMFS, USFWS, DWR, CDFW, CBDA	1	Long-term	$0	$0	$0	$0	$0	$0
Curtail further development in active Butte Creek floodplains through zoning restrictions, county master plans, and	2	BUC-2.8	SRCS, STE	Corps, NMFS, USFWS, DWR, CDFW, Local governments	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
other Federal, State, and county planning and regulatory processes.												
Develop education and outreach programs to encourage river stewardship in the Butte Creek watershed.	2	BUC-2.9	SRCS, STE	NMFS, USFWS, CDFW, DWR, CSU Chico, Landowners, schools	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Permanently protect riparian habitat in Butte Creek through easements and/or land acquisition	2	BUC-2.10	SRCS, STE	CDFW, Landowners, USFWS	1	Long-term	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Increase monitoring and enforcement in order to minimize illegal streambank alterations in Butte Creek, including high bank gold mining.	2	BUC-2.11	SRCS, STE	Corps, DWR, SWRCB	1,4,5	Long-term						Cost is covered under action # COC-2.9

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Increase water quality monitoring and enforcement in Butte Creek to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants (SWRCB 2007).	2	BUC-2.12	SRCS, STE	SWRCB, RWQCBs, Local agriculture groups	5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in Butte Creek.	2	BUC-2.13	SRCS, STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Dist, SWRCB, DWR, CDFW, Landowners	5	Long-term	$62,400	$0	$0	$0	$0	$62,400
Implement projects to increase Butte Creek floodplain habitat availability to improve habitat	2	BUC-2.14	SRCS, STE	NMFS, USFWS, CDFW, DWR	1,4	Long-term	TBD based on amount of habitat restored; initial study is expected to cost at least $50,000. Per unit cost is $5,000 to $80,000/acre (Appendix D Table	TBD	TBD	TBD	TBD	TBD based on amount of habitat restored; initial study is expected to cost at least $50,000. Per unit cost is $5,000 to $80,000/acre (Appendix D Table

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
conditions for juvenile rearing							HI-4).					HI-4).
Monitor and evaluate the sport fishing regulations for Butte Creek to ensure they are consistent with the recovery of spring-run Chinook salmon and steelhead, and work with the Fish and Game Commission to modify the regulations as needed.	2	BUC-2.15	SRCS, STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0
Develop, implement and evaluate a Butte Creek water management option for the PG&E DeSabla-Centerville Hydroelectric Project to determine the flow conditions that optimize coldwater holding habitat and spawning	2	BUC-2.16	SRCS, STE	CDFW, PG&E, FERC, NMFS	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in the FERC licensing process

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
distribution for spring-run Chinook salmon.												
Maintain state-of-the-art fish passage facilities at diversions in Butte Creek and DWR weir 2 to meet NMFS and CDFW fish passage criteria.	2	BUC-2.17	SRCS, STE	Irrigation districts, DWR	1,4	Long-term	$100,000	$100,000	$100,000	$100,000	$100,000	$500,000 over 25 years; ~$20,000 for each year after that. Estimate of $20,000/year is based on DWR (2004b).
Implement projects to minimize predation at weirs, diversion dams, and related structures in Butte Creek.	3	BUC-3.1	SRCS, STE	NMFS, CDFW, DWR, USFWS, USBR, Corps	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).

5.8.6 Feather River Recovery Actions

Table 5-18. Feather River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Establish reproductive isolation between fall-run Chinook salmon and spring-run Chinook salmon naturally spawning in the Feather River.	1	FER-1.1	SRCS	DWR, USFWS, NMFS, CDFW, FERC	1	Long-term	$0	$0	$0	$0	$0	$0 because this is an action required by a settlement agreement in FERC relicensing proceedings for DWR's Oroville Facilities hydroelectric project.
Develop and implement hatchery and genetic management plans for the spring-run Chinook salmon, steelhead, and fall-run Chinook salmon hatchery programs at the Feather River Fish Hatchery.	1	FER-1.2	SRCS, STE	DWR, USFWS, NMFS, CDFW, SWRCB, CVRWQCB, FERC	1,5	Long-term	$0	$0	$0	$0	$0	$0 because this is an action required by a settlement agreement in FERC relicensing proceedings for DWR's Oroville Facilities hydroelectric project.
Identify and implement actions intended to minimize straying of Feather River Hatchery salmon and steelhead.	1	FER-1.3	SRCS, STE	DWR, YCWA, USFWS, NMFS, CDFW, SWRCB, CVRWQCB, and FERC	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	The cost of hatchery measures are included in FER-1.2; the cost of any flow management measures are TBD in FERC licensing proceedings for projects on the Feather and Yuba Rivers.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop a spawning gravel budget, identify gravel depleted areas, and implement an augmentation plan in the Feather River.	1	FER-1.4	SRCS, STE	DWR, CDFW, USFWS, NMFS, SWRCB, and FERC	1	Long-term	$0	$0	$0	$0	$0	$0 because this is an action required by a settlement agreement in FERC relicensing proceedings for DWR's Oroville Facilities hydroelectric project.
Implement and maintain projects to increase side channel habitats in order to improve steelhead spawning habitat availability and quality.	1	FER-1.5	STE	DWR, CDFW, USFWS, NMFS, and FERC	1,4	Long-term	$0	$0	$0	$0	$0	$0 because this is an action required by a settlement agreement in FERC relicensing proceedings for DWR's Oroville Facilities hydroelectric project.
Operate the Feather River Hatchery programs for spring-run Chinook salmon and steelhead as conservation hatchery programs, and develop criteria and a process for phasing out the programs as recovery criteria are reached.	1	FER-1.6	SRCS, STE	NMFS, USFWS, CDFW, DWR	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement projects to minimize predation at weirs, diversion dams, and related structures in the Feather River.	1	FER-1.7	SRCS, STE	NMFS, CDFW, DWR, USFWS, USBR, Corps	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).
Implement the lower Feather River Corridor Management Plan and other projects that promote natural river processes (e.g., floodplain and riparian restoration). Federal, State, and local agencies should	1	FER-1.8	SRCS, STE	DWR, CDFW, Corps	1,4	Long-term	TBD	TBD	TBD	TBD	TBD	TBD. NMFS is in the process of obtaining the cost information from DWR.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
use their authorities to develop and implement programs and projects that focus on retaining, restoring and creating active floodplain and riparian corridors within their jurisdiction in the Feather River watershed.												
Implement projects to improve near shore refuge cover for salmonids in the Feather River to minimize predatory opportunities for striped bass and other non-native predators.	1	FER-1.9	SRCS, STE	DWR, CDFW, Corps	1,3,4	Short-term	TBD	TBD				TBD, based on the # of sites, amount of material needed, type of material, location of source material (onsite vs. imported), and placement method. Cost of initial study to address these issues is $5,000-$50,000. See Table H1-2 in Appendix D for cost per unit for various projects
Manage releases from Oroville Dam with instream flow schedules and criteria to provide suitable water temperatures for all life	1	FER-1.10	SRCS, STE	NMFS, USFWS, CDFW, DWR, SWRCB, FERC	1,5	Long-term	$0	$0	$0	$0	$0	$0, because this is an action required by a settlement agreement in FERC relicensing proceedings for DWR's Oroville Facilities hydroelectric project.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
stages, reduce stranding and isolation, protect incubating eggs from being dewatered, and promote habitat availability.												
Implement a habitat expansion plan that meets the criteria of the Habitat Expansion Agreement, or develop and implement a program to reintroduce spring-run Chinook salmon and steelhead to historic habitats upstream of Oroville Dam in the North Fork Feather River. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term	2	FER-2.1	SRCS, STE	NMFS, USFWS, CDFW, DWR, PG&E, USFS, FERC	1,5	Long-term	$200,000	$4,000,000	$15,000,000	$17,000,000	$14,000,000	$50,200,000 (Cost estimate is for reintroducing spring-run Chinook salmon and steelhead to the North Fork Feather River.)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
reintroduction program.												
Implement a habitat expansion plan that meets the criteria of the Habitat Expansion Agreement, or implement actions to enhance habitat conditions and improve access within the north fork Feather River upstream of Oroville Dam, including increasing minimum flows, providing passage at upstream dams, and assessing feasibility of passage improvement at natural barriers.	2	FER-2.2	SRCS, STE	NMFS, USFWS, CDFW, DWR, PG&E, USFS, FERC	1,4,5	Long-term	TBD	TBD	TBD	TBD	TBD	$50,000 for habitat evaluation and identification of specific enhancement actions; cost of actions TBD
Implement a study designed to develop quantitative estimates of	2	FER-2.3	SRCS, STE	NMFS, USFWS, CDFW, DWR	3,4	5 Years	$200,000-$400,000	$0	$0	$0	$0	$200,000-$400,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
predation on spring-run Chinook salmon and steelhead in the Feather River.												
Implement programs and measures designed to minimize predation on juvenile salmonids in the Feather River, including harvest management techniques and programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).	2	FER-2.4	SRCS, STE	NMFS, USFWS, CDFW, DWR	2,3,4	Long-term						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).
Curtail further development in the active Feather River floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	2	FER-2.5	SRCS, STE	Corps, NMFS, USFWS, DWR, CDFW, Local governments	1,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Utilize fish friendly designs (e.g., levee setbacks, inclusion of riparian vegetation) for levee construction and maintenance.	2	FER-2.6	SRCS, STE	Corps, SWRCB	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop education and outreach programs to encourage river stewardship in the Feather River, including how to identify and avoid damaging salmon and steelhead redds.	2	FER-2.7	SRCS, STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, DWR, CDFW, CSU Chico, Landowners, schools, Feather River Nature Center	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Permanently protect Feather River riparian and floodplain habitat through easements and/or land acquisition.	2	FER-2.8	SRCS, STE	NMFS, CDFW, DWR, Corps	1,5	Long-term	TBD based on amount specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on amount specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Monitor and evaluate the sport fishing regulations for the Feather River to ensure they are consistent with the recovery of	2	FER-2.9	SRCS, STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
spring-run Chinook salmon and steelhead.												
Negotiate agreements with landowners and Federal and State agencies to provide additional instream flows or purchase water rights in the Feather River.	2	FER-2.10	SRCS, STE	USFWS, NMFS, Corps, USBR, Resource Conservation Districts, CDFW, DWR, Water districts, Landowners, Local governments, NGOs	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water. Cost per unit is $43 - $88/af/year for upstream of Delta water purchases (Appendix D)
Evaluate pulse flow benefits in the Feather River for adult immigration and juvenile outmigration during peak migration periods for years with low water availability; if pulse flows are determined to be effective for attracting adult spring-run Chinook salmon and steelhead or for improving survival during juvenile	2	FER-2.11	SRCS, STE	DWR, USFWS, NMFS, CDFW, FERC, YCWA, PG&E, NID	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in FERC license proceedings.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
outmigration, implement the most beneficial pulse flow regime.												
Develop an entrainment and predator monitoring program in the Feather River to determine the level of take at individual diversions and screen those with the highest take level relative to screen cost.	2	FER-2.12	SRCS, STE	NMFS, CDFW, Irrigation districts, Water districts	1,3,5	5 years	$100,000 for monitoring program; screening costs are TBD.	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).
Modify Sunset Pumps to provide unimpeded upstream passage of adult steelhead and Chinook salmon (and sturgeon) and to minimize predation of juveniles moving downstream.	2	FER-2.13	SRCS, STE	DWR	1,3,5	Short-term	$50,000 to identify and design a preferred modification; cost of modification TBD after the initial study.	$0	$0	$0	$0	$50,000 to identify and design a preferred modification; cost of modification TBD after the initial study.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop a baseline monitoring program in the Feather River to evaluate water quality throughout the watershed to identify areas of concern and disseminate the information to resource managers.	2	FER-2.14	SRCS, STE	DWR, CDFW	1,5	3 Years	$0	$0	$0	$0	$0	$0
Develop and apply alternative diversion technologies that eliminate entrainment in the Feather River.	3	FER-3.1	SRCS, STE	NMFS, CDFW, Irrigation districts, Water districts	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD. This action involves development of a new technology such that is impracticable to provide a reasonable estimate of the action's cost.
Implement pollution control programs and projects to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met in the Feather River for all potential pollutants.	3	FER-3.2	SRCS, STE	SWRCB, CVRWQCB, Local agriculture groups	1,5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Pursue grant funding or cost-share payments for landowners to prepare plans and implement best-management practices to reduce water quality impacts in the Feather River watershed.	3	FER-3.3	SRCS, STE	USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW	1,5	Long-term	$62,400	$0	$0	$0	$0	$62,400

5.8.7 Yuba River Recovery Actions

Table 5-19. Yuba River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement a program to reintroduce spring-run Chinook salmon and steelhead to historic habitats upstream of Englebright Dam. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term reintroduction program.	1	YUR-1.1	SRCS, STE	NMFS, USFWS, USFS, CDFW, Corps, PG&E, NIC, YCWA, FERC	1, 4	Long-term: Evaluations beginning in year 1 , Pilot	$200,000	$4,000,000	$15,000,000	$17,000,000	$14,000,000	$50,200,000
Improve spawning habitat in the Englebright Dam Reach (Englebright Dam [RM 24] downstream to the Deer Creek confluence	1	YUR-1.2	SRCS, STE	NMFS, USFWS, Corps, CDFW	1	Long-term	$5.9 million for spawning rehabilitation (DWR and PG&E 2010)	$800,000 for maintenance	$800,000 for maintenance	$800,000 for maintenance	$800,000 for maintenance	$9, 900,000 over 25 years; $800,000 for each additional 5-year block.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
[RM 23]) through habitat rehabilitation and a long-term gravel injection program (Pasternack 2009).												
Develop programs and implement projects that promote natural river processes, including projects that add riparian habitat and instream cover.	1	YUR-1.3	SRCS, STE	YCWA, Corps, CDFW, SYRCL, USFS, USFWS	1	Long-term	$4,217,625	$0	$0	$0	$0	$4,217,625
Modify Daguerre Point Dam to provide unobstructed volitional upstream passage of adult steelhead and Chinook salmon (and sturgeon) and to minimize predation of juveniles moving downstream.	1	YUR-1.4	SRCS, STE	YCWA, Corps, CDFW, SYRCL, USFWS	1,4	Long-term	Cost estimates for fish passage alternatives range from $2.5 million to construct an engineered channel to $97 million to remove the dam (DWR and Corps 2003).	Operation and maintenance costs range from $50,000 to $2,000,000 per year (DWR and Corps 2003)	Operation and maintenance costs range from $50,000 to $2,000,000 per year (DWR and Corps 2003)	Operation and maintenance costs range from $50,000 to $2,000,000 per year (DWR and Corps 2003)	Operation and maintenance costs range from $50,000 to $2,000,000 per year (DWR and Corps 2003)	$3.5 million to $137 million based on DWR and Corps (2003) estimates, and assuming construction during years 1-5 and operation and maintenance costs during years 6-25.
Develop and implement a large woody material restoration	2	YUR-2.1	SRCS, STE	NMFS, USFWS, Corps, USBR, DWR, CDFW	1	Long-term	$750,000 - $2,000,000	$750,000 - $2,000,000	$750,000 - $2,000,000	$750,000 - $2,000,000	$750,000 - $2,000,000	$3,750,000 - $10,000,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
program along the lower Yuba River utilizing sources of wood that enter upstream reservoirs.												
Increase floodplain habitat availability in the lower Yuba River.	2	YUR-2.2	SRCS, STE	CDFW, USFWS, NMFS, YCWA	1	Long-term	TBD	TBD	TBD	TBD	TBD	TBD based on several factors including: (1) how much floodplain habitat is to be restored; (2) the amount of material that needs to be removed; (3) whether the removed material can be sold and at what price; and (4) whether the newly available floodplain is planted or vegetation is allowed to colonize naturally. Initial evaluation to address these factors estimated at up to $200,000.
Curtail further development in active Yuba River floodplains through zoning restrictions, county master plans, and other Federal, State, and	2	YUR-2.3	SRCS, STE	YCWA, Corps, CDFW, SYRCL, USFS, FERC, USFWS	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
county planning and regulatory processes.												
Create and restore side channel habitats to increase the quantity and quality of off-channel rearing and spawning areas in the Yuba River.	2	YUR-2.4	SRCS, STE	YCWA, Corps, CDFW, SYRCL, USFS, FERC, USFWS	1	Short-term	TBD	TBD				TBD based on the amount of side channel habitat restoration. Unit cost is $20,000 to $300,000/acre (Appendix D). Initial evaluation estimated at $5,000-$50,000
Federal, State, and local agencies should use their authorities to develop and implement programs and projects that focus on retaining, restoring and creating river riparian corridors within their jurisdiction in the Yuba River watershed.	2	YUR-2.5	SRCS, STE	NMFS, USWS, FERC, CDFW, DWR, YCWA	1	Long-term	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$150,000 - $675000
Permanently protect Yuba River riparian and floodplain habitat through easements and/or land	2	YUR-2.6	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR, Yuba Watershed Council	1	Long-term	TBD based on specific easements and land acquisitions; initial study is expected	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
acquisition.							to cost at least $50,000.					
Implement flow fluctuation and ramping rates found to be protective of embryos and juveniles.	1	YUR-2.7	SRCS, STE	YCWA, NMFS, USFWS, Corps, CDFW, DWR, PG&E, NID, SYRCL, Yuba Watershed Council	1	Long-term	Costs TBD in FERC licensing proceedings	Costs TBD in FERC licensing proceedings	Costs TBD in FERC licensing proceedings	Costs TBD in FERC licensing proceedings	Costs TBD in FERC licensing proceedings	Costs TBD in FERC licensing proceedings
Implement programs and measures designed to minimize predation by non-native fish in the Yuba River, including harvest management techniques and programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).	2	YUR-2.8	SRCS, STE	NMFS, USFWS, CDFW, DWR, YCWA, South Yuba and Brophy Water Districts	2,3	Long-term						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).
Improve efficiency of screening devices at Hallwood-Cordua and Brophy-South Yuba water diversions, and	2	YUR-2.9	SRCS, STE	NMFS, CDFW, YCWA, South Yuba and Brophy Water Districts	1,4	Short-term	$200,000	$0	$0	$0	$0	$200,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
construct screens at unscreened diversions												
Evaluate whether salmonid straying between the Feather and Yuba rivers can be minimized through flow management.	2	YUR-2.10	SRCS, STE	NMFS, USFWS, Corps, DWR, YCWA	1,4	Short-term	$5,000 for initial study to develop goals, objectives, experimental design, and statistical analysis; cost of the evaluation is TBD based on the initial study.	TBD	TBD	TBD	TBD	$5,000 for initial study to develop goals, objectives, experimental design, and statistical analysis; cost of the evaluation is TBD based on the initial study.
Monitor and evaluate the sport fishing regulations for the Yuba River to ensure they are consistent with the recovery of spring-run Chinook salmon and steelhead.	2	YUR-2.11	SRCS, STE	NMFS, CDFW,SYRCL, Yuba Watershed Council	2	Short-term	$0	$0	$0	$0	$0	$0
Relocate the riverside motocross recreation area outside of the Yuba River's active floodplain.	3	YUR-3.1	SRCS, STE	CDFW, Yuba County, Yuba Watershed Council	2	5 Years	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap in the Yuba River.	3	YUR-3.2	SRCS, STE	NMFS, USFWS, USBR, DWR, CDFW, CBDA	1	Long-term	$0	$0	$0	$0	$0	$0
Identify the benefits, risks, and costs associated with various techniques and locations for spatially segregating spring-run Chinook salmon and fall-run Chinook salmon during spawning in the Yuba River. If the benefits sufficiently outweigh the risks and costs, then implement a project to segregate spring- and fall-run Chinook salmon.	3	YUR-3.3	SRCS, STE	NMFS, CDFW, YCWA, Yuba Watershed Council, PG&E	1	Short-term	$10,000 for benefit, risk, and cost evaluation. Cost of segregation TBD based on the evaluation.	$0	$0	$0	$0	$10,000 for benefit, risk, and cost evaluation. Cost of segregation TBD based on the evaluation.

5.8.8 Dry Creek Recovery Actions

Table 5-20. Dry Creek Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Conduct an anadromous fish passage assessment in Dry Creek and implement projects to fix any obstructions.	3	DRC-3.1	STE	NMFS, USFWS, USFS, CDFW, DWR, Yuba Watershed Council, Bear River Watershed Group	1	5 Years	$50,000-$200,000, fish passage project(s) cost TBD by the assessment.	$0	$0	$0	$0	$50,000-$200,000, fish passage project(s) cost TBD by the assessment.
Enhance watershed resiliency in Dry Creek by identifying and implementing projects that would reduce the potential for, and magnitude of, a catastrophic wildfire, and restore forested areas within the watershed including riparian areas.	3	DRC-3.2	STE	NMFS, USFWS, USFS, CDFW, DWR, Yuba Watershed Council, Bear River Watershed Group	1	Long-term	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the Dry Creek watershed.	3	DRC-3.3	STE	NMFS, USFWS, National Park Service, SWRCB, DWR, CDFW, Dry Creek Conservancy, Placer County, Sierra College	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop education and outreach programs to encourage river stewardship in Dry Creek.	3	DRC-3.4	STE	NMFS, USFWS, National Park Service, SWRCB, DWR, CDFW, Dry Creek Conservancy, Placer County, Sierra College	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in the Dry Creek watershed.	3	DRC-3.5	STE	NMFS, USFWS, National Park Service, SWRCB, DWR, CDFW, Dry Creek Conservancy, Placer County, Sierra College	1,5	Long-term	$62,400	$0	$0	$0	$0	$62,400
Develop a long-term strategy for monitoring and regulating discharges from agricultural lands in the Dry Creek watershed to protect waters within the Central Valley, including enforcing the regulations.	3	DRC-3.6	STE	SWRCB, NRCS, Placer County	1,5	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement in Dry Creek to ensure that the water quality criteria established in the Central	3	DRC-3.7	STE	SWRCB, CVRWQCB, Local agriculture groups	1,5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants.												
Conduct a hydrologic analysis of the Dry Creek watershed that explores conjunctive use opportunities to reduce water allocations that are dependent on surface water.	3	DRC-3.8	STE	NMFS, USFWS, National Park Service, SWRCB, DWR, CDFW, Dry Creek Conservancy, Placer County, Sierra College	1	Long-term	$275,550	$0	$0	$0	$0	$275,550
Evaluate gravel resources on Dry Creek and provide gravel at any identified locations.	3	DRC-3.9	STE	NMFS, USFWS, National Park Service, SWRCB, DWR, CDFW, Dry Creek Conservancy, Placer County, Sierra College	1,5	Short-term	$5,000-$50,000 for evaluation; gravel augmentation costs TBD based on the evaluation.	$0	$0	$0	$0	$5,000-$50,000 for evaluation; gravel augmentation costs TBD based on the evaluation.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Curtail further development in the active Dry Creek floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	3	DRC-3.10	STE	NMFS, USFWS, National Park Service, SWRCB, DWR, CDFW, Dry Creek Conservancy, Placer County, Sierra College	1,5	Long-term	$0	$0	$0	$0	$0	$0
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap in Dry Creek.	3	DRC-3.11	STE	NMFS, USFWS, Corps, USBR, CDFW, DWR, CBDA	1	Long-term	$0	$0	$0	$0	$0	$0
Permanently protect Dry Creek riparian habitat through easements and/or land acquisition	3	DRC-3.12	STE		1,5	Long-term	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Monitor and evaluate the sport fishing regulations for Dry Creek to ensure they are consistent with the recovery of steelhead.	3	DRC-3.13	STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0
Implement programs and measures designed to control non-native predatory fish in Dry Creek (NMFS 2007b), including harvest management techniques and programs for non-native predators (e.g., striped bass, largemouth bass, and smallmouth bass).	3	DRC-3.14	STE	NMFS, USFWS, CDFW, DWR	1,3	Long-term						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).
Implement projects to minimize predation at weirs, diversion dams, and related structures in Dry Creek.	3	DRC-3.15	STE	NMFS, CDFW, DWR, USFWS, USBR, Corps	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
							site-specific costs.					specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).
Improve instream refuge cover for salmonids in Dry Creek to minimize predatory opportunities for striped bass and other non-native predators.	3	DRC-3.16	STE	NMFS, USFWS, CDFW, DWR	1,3	Long-term	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and placement method. Initial scoping to address those issues would cost at least $50,000. See Table H1-2 in Appendix D for cost per unit for various projects.	TBD	TBD	TBD	TBD	TBD, based on the # of sites, amount of material needed, type of material, location of source material (onsite vs. imported), and placement method. Cost of initial study to address these issues is $5,000-$50,000. See Table H1-2 in Appendix D for cost per unit for various projects

5.8.9 Auburn Ravine Recovery Actions

Table 5-21. Auburn Ravine Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Install a fish ladder at Gold Hill Dam and screen the diversion canal.	2	AUR-2.1	SRCS, STE	SWRCB, CVRWQCB, Local farmers, SARSAS	1,5	5 Years	<$1 million	$0	$0	$0	$0	<$1 million
Develop an entrainment monitoring program in Auburn Ravine and Coon Creek to determine the level of take at individual diversions. Prioritize diversions based on this monitoring and screen those that are determined to have substantial impacts at the population level.	2	AUR-2.2	STE	NMFS, USFWS, CDFW, DWR, Placer County, Irrigation districts, SARSAS	1,3,5	5 years	$100,000 for monitoring program; screening costs for Auburn Ravine are TBD.	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).
Develop and apply alternative diversion technologies that eliminate entrainment in Auburn Ravine and Coon Creek.	2	AUR-2.3	STE	NMFS, USFWS, CDFW, DWR, Placer County, Irrigation districts, SARSAS	1	Long-term	TBD	TBD	TBD	TBD	TBD	TBD. ·This action involves development of a new technology such that is impracticable to provide a reasonable estimate of the action's cost.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement projects that consolidate and screen existing diversions in Auburn Ravine and Coon Creek where feasible.	2	AUR-2.4	STE	NMFS, USBR, CDFW, DWR, Irrigation districts, Water districts, SARSAS	1,3,5	Long-term	$200,000	$200,000	$0	$0	$0	$400,000
Conduct a hydrologic analysis of the Auburn/Coon Creek watershed that explores conjunctive use opportunities to reduce water allocations that are dependent on surface water.	2	AUR-2.5	STE	NMFS, USFWS, Corps, USBR, CDFW, DWR, SARSAS, PCWA	5	Long-term	$275,550	$0	$0	$0	$0	$275,550
Enhance watershed resiliency in Auburn Ravine and Coon Creek by identifying and implementing projects that would reduce the potential for, and magnitude of, a catastrophic wildfire, and restore forested areas within the watershed including riparian areas.	2	AUR-2.6	STE	NMFS, USFWS, USFS, CDFW, DWR, Placer County, SARSAS, PCWA	1	Long-term	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBE	TBD	TBD based on amount and type of habitat restored; initial study is expected to cost at least $50,000.
Continue to implement projects designed to minimize chronic road-related erosion on public and private lands in the	2	AUR-2.7	STE	NMFS, USFWS, USFS, CDFW, Placer County, SARSAS	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Auburn Ravine and Coon Creek watershed.												
Develop a baseline monitoring program in Auburn Ravine and Coon Creek to evaluate water quality throughout the watershed to identify areas of concern.	2	AUR-2.8	STE	NMFS, USFWS, USEPA, SWRCB, DWR, CDFW, Placer County, SARSAS	5	3 Years	$0	$0	$0	$0	$0	$0
Develop education and outreach programs to encourage river stewardship in the Auburn Ravine/Coon Creek watershed.	2	AUR-2.9	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW, Landowners, Placer County, SARSAS, PCWA	2	Long-term	$76,140	$76,140	$76,140	$76,140	$0	$304,560

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in the Auburn Ravine/Coon Creek watershed.	2	AUR-2.10	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW, Placer County, Local farmers	5	Long-term	$62,400	$0	$0	$0	$0	$62,400
Develop a long-term strategy for monitoring and regulating discharges from agricultural lands in the Auburn Ravine/Coon Creek watershed to protect waters within the Central Valley, including enforcing the regulations.	2	AUR-2.11	STE	SWRCB, Local farmers	5	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement in Auburn Ravine and Coon Creek to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met (SWRCB 2007).	2	AUR-2.12	STE	SWRCB, CVRWQCB, Local agriculture groups	1,5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Identify stream reaches in Auburn Ravine and Coon Creek that have been most altered by anthropogenic factors and reconstruct a natural channel geometry scaled to current channel forming flows.	2	AUR-2.13	STE	NMFS, USFWS, CDFW, DWR, SARSAS	5	5 Years	$4,217,625	$0	$0	$0	$0	$4,217,625
Curtail further development in the active Auburn Ravine and Coon Creek floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	2	AUR-2.14	STE	NMFS, USFWS, Corps, USFS, DWR, CDFW, Local governments	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop State and national levee vegetation policies to maintain and restore riparian corridors in Auburn Ravine and Coon Creek (Corps vegetation management policy and FloodSAFE).	2	AUR-2.15	STE	NMFS, USFWS, Corps, USBR, CDFW, DWR	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement programs and projects that focus on retaining, restoring and creating river riparian corridors within their jurisdiction in the Auburn Ravine/Coon Creek watershed.	2	AUR-2.16	STE	NMFS, USFWS, Corps, USBR, USFS, DWR, CDFW, Local agencies, NGOs	1,5	Short-term	TBD	TBD	$0	$0	$0	TBD based on amount of riparian habitat to be restored. As identified in Appendix D, per unit costs vary depending on whether fencing, planting, irrigation, or invasive week control are needed. Initial scoping study estimated to cost $5,000-$50,000.
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap in Auburn Ravine and Coon Creek.	2	AUR-2.17	STE	NMFS, USFWS, Corps, USBR, DWR, CDFW, CBDA	1	Long-term	$0	$0	$0	$0	$0	$0
Permanently protect Auburn and Coon Creek riparian habitat through easements and/or land acquisition	2	AUR-2.18	STE	NMFS, USFWS, CDFW, DWR, SARSAS	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Implement programs and measures in Auburn Ravine and Coon Creek designed to control non-native predators.	2	AUR-2.19	STE	NMFS, USFWS, CDFW, DWR, SARSAS	1,3	Long-term	Cost covered by the cost of SFB-2.5 ($0-$75,000,000).	TBD	TBD	TBD	TBD	Cost covered by the cost of SFB-2.5 ($0-$75,000,000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement projects to minimize predation at weirs, diversion dams, and related structures in Auburn Ravine and Coon Creek.	2	AUR-2.20	STE	NMFS, CDFW, DWR, USFWS, USBR, Corps, SARSAS	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs. P	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).
Improve instream refuge cover for salmonids in Auburn Ravine and Coon Creek to help minimize predation.	2	AUR-2.21	STE	NMFS, USFWS, CDFW, DWR, SARSAS	1,3	Long-term	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and placement method. Initial scoping to address those issues would cost at least $50,000. See Table H1-2 in Appendix D for cost per unit for various projects.	TBD	TBD	TBD	TBD	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and placement method. Initial scoping to address those issues would cost at least $50,000. See Table H1-2 in Appendix D for cost per unit for various projects.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Monitor and evaluate the sport fishing regulations for Auburn Ravine and Coon Creek to ensure they are consistent with the recovery of steelhead.	3	AUR-3.1	STE	NMFS, CDFW	1,2	Long-term	$0	$0	$0	$0	$0	$0

5.8.10 American River Recovery Actions

Table 5-22. American River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement a steelhead reintroduction plan to re-colonize historic habitats above Nimbus and Folsom Dams: Conduct feasibility study; Conduct habitat evaluations; Conduct 3-5 year pilot testing program; and Implement long-term fish passage.	1	AMR-1.1	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW, FERC, PG&E, PCWA	1,5	Long-term: Evaluations beginning in year 1	$200,000	$4,000,000	$15,000,000	$17,000,000	$14,000,000	$50,200,000
Implement physical and structural modifications to the American River Division of the CVP in order to improve water temperature management (See RPA action II.3 in the 2009 Biological Opinion for the long-term operations of the CVP and SWP) (NMFS 2009b).	1	AMR-1.2	STE	NMFS, USFWS, Corps, USBR, DWR, CDFW, CBDA, Water Forum	1,4	Long-term	$0	$0	$00	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop an annual water temperature management plan for the lower American River (NMFS 2009b).	1	AMR-1.3	STE	USFWS, USBR, CDFW, DWR, Water Forum	1,5	Long-term	$0	$0	$0	$0	$0	$0
Implement the flow management related actions (i.e., RPA actions II.1 and II.4) identified in the reasonable and prudent alternative from the 2009 Biological Opinion for the long-term operations of the CVP and SWP (NMFS 2009b).	1	AMF-1.4	STE	USFWS, USBR, CDFW, DWR, Water Forum	1,4	Long-term	$0	$0	$0	$0	$0	$0
Implement a long-term gravel management program in the lower American River to provide suitable spawning habitat per CVPIA.	1	AMR-1.5	STE	USFWS, USBR, Water Forum	1,4	Long-term	$1,000,000[28]	$1,000,000	$1,000,000	$1,000,000	$1,000,000	$5,000,000
Implement a long-term wood management program to provide habitat	1	AMR-1.6	STE	USFWS, USBR, CDFW, Water Forum	1,4,5	Long-term)	$100,000	$200,000	$250,000	$300,000	$300,000	$1,150,000

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[28] Based on cost of 2013-2016 CVPIA funded gravel augmentation project for the American River.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
complexity and predator refuge habitat.												
Implement the recommendations of the 2012 California Hatchery Scientific Review Group Report regarding the steelhead program at Nimbus Hatchery.	1	AMR-1.7	STE	USBR, CDFW	4,5	Long-term	$0	$0	$0	$0	$0	$0
Develop and implement a HGMP for the steelhead program at Nimbus Hatchery (NMFS 2009b).	1	AMR-1.8	STE	USBR, CDFW	2,5	Long-term	$0	$0	$0	$0	$0	$0
Develop a baseline monitoring program in the American River watershed to evaluate water quality throughout the watershed to identify areas of concern.	2	AMR-2.1	STE	NMFS, USFWS, USEPA, SWRCB, DWR, CDFW	1,5	3 Years	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement in the American River watershed to ensure that the water quality	2	AMR-2.2	STE	SWRCB, CVRWQCB	1,4	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants.												
Implement projects that improve wastewater and stormwater treatment in residential, commercial, and industrial areas throughout the American River watershed.	2	AMR-2.3	STE	NMFS, CDFW, SWRCB, Water Forum, Sacramento County and cities germane to this issue.	4,5	Long-term	TBD	TBD	TBD	TBD	TBD	Cost partly covered in DEL-2.20 ($1-$2 billion). Other costs TBD based on site-specific evaluations, each of which could range up to $100,000.
Develop education and outreach programs to encourage river stewardship in the American River watershed.	2	AMR-2.4	STE	Corps, NMFS, USFWS, DWR, CDFW, American River Conservancy, Local government, Water Forum	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Develop and implement programs and projects that focus on retaining, restoring and creating river riparian corridors within their	2	AMR-2.5	STE	NMFS, USFWS, Corps, USBR, USFS, DWR, CDFW, Local agencies, NGOs	1,4	Long-term	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$150,000 -$675,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
jurisdiction in the American River watershed.												
Permanently protect American River riparian habitat through easements and/or land acquisition	2	AMR-2.6	STE	Local govt, Corps, SAFCA, CDFW	1,5	short-term	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap in the American River.	2	AMR-2.7	STE	Corps, USBR, NMFS, USFWS, DWR, CDFW, CBDA	1	Long-term	$0	$0	$0	$0	$0	$0
Curtail further development in active American River floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	2	AMR-2.8	STE	Corps, NMFS, USFWS, USFS, DWR, CDFW, Local governments	1,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Inventory locations on the American River for creating shallow inundated floodplain habitat for multi-species benefits and implement where suitable opportunities are available (Water Forum 2001).	2	AMR-2.9	STE	NMFS, USFWS, USBR, Corps, CDFW, DWR, Water Forum	1	Long-term	$0	$0	$0	$0	$0	$0
Modify sport-fishing regulations to minimize "take" of wild steelhead and to minimize hatchery influence in the lower American River. This could include increased information in the regulations about not wading through redds and increasing the bag and possession limit for hatchery steelhead.	3	AMR-3.1	STE	NMFS, CDFW	2,5	short-term	$0	$0	$0	$0	$0	$0

5.8.11 Mokelumne River Recovery Actions

Table 5-23. Mokelumne River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Adaptively manage water releases in the Mokelumne River in consideration of the spatial and temporal distribution of steelhead life stages in the Mokelumne River.	1	MOR-1.1	STE	NMFS, USFWS, CDFW, DWR, Landowners, Irrigation districts	1	Long-term	$0	$0	$0	$0	$0	$0
Manage cold water pools in Camanche and Pardee reservoirs to provide suitable water temperatures in the Mokelumne River for all steelhead life stages.	1	MOR-1.2	STE	NMFS, USFWS, USBR, CDFW, EBMUD	1	Long-term	$278,030 for evaluation of alternative reservoir management practices; cost of any operational changes TBD based on the evaluation.	TBD	TBD	TBD	TBD	$278,030 for evaluation of alternative reservoir management practices; cost of any operational changes TBD based on the evaluation.
Implement the recommendations of the 2012 California Hatchery Scientific Review Group Report regarding the steelhead program at Mokelumne Hatchery.	1	MOR-1.3	STE	NMFS, USFWS, CDFW, DWR	4, 5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD; Specific actions to be taken and associated costs will be identified by the Mokelumne River Hatchery Coordination Team that will be formed according to the recommendation from the Hatchery Scientific Review Group.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Continue to develop and implement a spawning gravel augmentation plan for the Mokelumne River.	2	MOR-2.1	STE	NMFS, USFWS, USBR, CDFW, DWR	1,5	Long-term	$50,000 for plan development; gravel augmentation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD
Conduct feasibility studies for allowing steelhead access to habitat above Camanche and Pardee dams, including assessing habitat suitability and fish passage logistics.	2	MOR-2.2	STE	NMFS, USFWS, USBR, DWR, PG&E, FERC	1	Short-term	$720,000	$0	$0	$0	$0	$720,000
If the feasibility studies suggest that fish passage can be successful, then design and conduct an experimental fish passage program evaluating adult distribution, survival, spawning, and juvenile production in habitats above Camanche and Pardee dams.	2	MOR-2.3	STE	NMFS, USFWS, USBR, DWR	1	Short-term	$0	$9,000,000	$0	$0	$0	$9,000,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
If the experimental fish passage program demonstrates that passage above Camanche and Pardee dams can substantively contribute to the long-term viability of the DPS, then develop and implement long-term fish passage programs.	2	MOR-2.4	STE	NMFS, USFWS, USBR, DWR	1	Long-term	$0	$0	$3,500,000	$3,500,000	$3,500,000	10,500,000
Evaluate the adequacy of the existing flow regime through SWRCB processes, and dedicate flows as necessary.	2	MOR-2.5	STE	NMFS, USFWS, CDFW, SWRCB	1,5	Long-term	$0	$0	$0	$0	$0	$0
Negotiate agreements with landowners, water districts, and Federal and State agencies to provide additional instream flows or purchase water rights, and/or restore riparian habitat to promote shading in the Mokelumne River.	2	MOR-2.6	STE	USFWS, NMFS, Corps, USBR, Resource Conservation Districts, CDFW, DWR, Water Districts, Landowners, Local governments, NGOs	1, 5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on : (1) amount of water. Cost per unit is $43 - $88/af/year for upstream of Delta water purchases (Appendix D); and (2) amount of habitat restored. As identified in Appendix D, per unit costs for riparian restoration vary depending on whether fencing, planting, irrigation, or invasive weed control are needed. Evaluation of water available for acquisition and riparian habitat

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												restoration opportunities could range up to $100,000.
Evaluate pulse flow benefits for steelhead attraction and passage in the Mokelumne River; if pulse flows are determined to be effective for attracting steelhead, implement the most beneficial pulse flow regime.	2	MOR-2.7	STE	NMFS, USFWFS, USBR, CDFW, DWR	1	Long-term	$0	$0	$0	$0	$0	$0
Monitor and evaluate sport-fishing regulations to ensure that angling impacts on steelhead in the Mokelumne River are consistent with recovery.	2	MOR-2.8	STE	NMFS, CDFW	1, 2	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement outreach projects in the Mokelumne River basin to educate the public regarding the steelhead life cycle and watershed stewardship.	2	MOR-2.9	STE	NMFS, USFWS, USBR, CDFW, DWR	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in the Mokelumne River.	2	MOR-2.10	STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, CDFW, DWR, Landowners	1, 5	Long-term	$62,400	$0	$0	$0	$0	$62,400
Increase monitoring and enforcement in the Mokelumne River to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants.	2	MOR-2.11	STE	SWRCB, CVRWQCB, Local agriculture	1, 5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Work with local land owners to restore riparian habitats in the Mokelumne River.	2	MOR-2.12	STE	NMFS, USFWS, Resource Conservation Districts, CDFW, DWR	1, 5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of habitat restored. As identified in Appendix D, per unit costs vary depending on whether fencing, planting, irrigation, or invasive weed control are needed.$5,000-$50,000 for initial scoping evaluation.
Permanently protect Mokelumne River riparian habitat through easements and/or land acquisition	2	MOR-2.13	STE	NMFS, USFWS, Resource Conservation Districts, CDFW, DWR	1, 5	Long-term	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Conduct research and monitoring to better understand the factors affecting the survival of steelhead downstream of Woodbridge Dam.	2	MOR-2.14	STE	EBMUD, CDFW, USFWS, NMFS	1,5	Short-term	$5,000 for initial study to develop goals, objectives, experimental design, and statistical analysis; cost of the research and monitoring is TBD based on the initial study.	TBD	$0	$0	$0	$5,000 for initial study to develop goals, objectives, experimental design, and statistical analysis; cost of the research and monitoring is TBD based on the initial study.
Implement projects to minimize predation in the Mokelumne River.	2	MOR-2.15	STE	EBMUD, CDFW, USFWS, NMFS	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
							for potential site-specific costs.					details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).
Implement projects to minimize entrainment in the Mokelumne River.	2	MOR-2.16	STE	EBMUD, CDFW, USFWS, NMFS	1	Short-term	TBD based on number of diversions and site specific factors affecting screening costs. $5,000-$50,000 for initial scoping evaluation.	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).

5.8.12 Cosumnes River Recovery Actions

Table 5-24. Cosumnes River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop cooperative water use agreements (e.g., groundwater exchange agreements) with local water users to provide flows in the Cosumnes River.	3	COR-3.1	STE	CDFW, USFWS, NMFS, water districts	1	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water. Cost per unit is $43 - $88/af/year for upstream of Delta water purchases (Appendix D)
Implement projects to minimize predation in the Cosumnes River	3	COR-3.2	STE	CDFW, USFWS, NMFS	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												assumed that each site will cost about $38,000 annually (BDCP 2013).
Implement projects to minimize entrainment in the Cosumnes River.	3	COR-3.3	STE	CDFW, USFWS, NMFS, water districts	1,5	Short-term	TBD based on number of diversions and site specific factors affecting screening costs. $5,000-$50,000 for initial scoping evaluation.	TBD	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).

5.9 Mainstem San Joaquin River Recovery Actions

Table 5-25. San Joaquin River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement the Exhibit B hydrographs providing interim and restoration flows as outlined in the San Joaquin River Stipulation of Settlement (available at http://www.restoresjr.net/).	1	SJR-1.1	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,4	Long-term	$0	$0	$0	$0	$0	$0
Develop and implement a spring-run Chinook salmon reintroduction strategy as outlined in paragraph 14 of the San Joaquin River Stipulation of Settlement (available at http://www.restoresjr.net/).	1	SJR-1.2	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,4	Long-term	$0	$0	$0	$0	$0	$0
Implement channel modifications as outlined in the San Joaquin River Stipulation of Settlement, including increasing the channel capacity to accommodate restoration flows up to 4,500 cfs (available at http://restoresjr.net/).	1	SJR-1.3	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,4	Long-term	$0	$0	$0	$0	$0	$0
Minimize entrainment and fish losses to both adult and juvenile life stages to non-viable migration pathways as outlined in the San Joaquin River Stipulation of Settlement, including, placing temporary barriers at Mud and Salt Sloughs and other potential sources of adult entrainment, screening	1	SJR-1.4	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Arroyo Canal and other riparian diversions as they are identified, and modifying and screening the Chowchilla Bypass Bifurcation Structure (available at http://www.restoresjr.net/).												
Provide fish passage at existing structures as outlined in the San Joaquin River Stipulation of Settlement (available at http://restoresjr.net/) including: (1) modifications to the Sand Slough Control Structure; (2) modification of the Reach 4B head gate; (3) reconstruction of Sack Dam to ensure unimpeded fish passage; (4) construction of a Mendota Pool Bypass; (5) modifications to structures in the Eastside and Mariposa Bypasses channels; and (6) fixing other passage impediments including road crossings, drop structures, and others as identified in the DWR Passage Report (DWR 2012) for the San Joaquin River Restoration Area.	1	SJR-1.5	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Manage juvenile salmonid predation risk by filling and/or isolating high priority gravel pits as identified in paragraph 11(b) of the San Joaquin River Stipulation of Settlement (available at http://www.restoresjr.net/).	1	SJR-1.6	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,4	Long-term	$0	$0	$0	$0	$0	$0
Develop and implement an ecologically based San Joaquin River flow regime to help restore natural river processes and support all life stages of steelhead and spring-run Chinook salmon (Poff *et al.*1997).	1	SJR-1.7	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR, SWRCB	1,4	Long-term	$4,217,625	$4,217,625	$4,217,625	$4,217,625	$0	$16,870,500
Implement projects that improve wastewater and stormwater treatment in residential, commercial, and industrial areas throughout the San Joaquin River watershed to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants.	1	SJR-1.8	SRCS, STE	NMFS, USFWS, CDFW, DWR, SWRCB, Local governments	1,4,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD based on amount of water to be treated and whether existing treatment facilities need to be upgraded or new facilities are required.. Site-specific evaluations could range up to $100,000 each.
Develop a long-term strategy for monitoring and regulating discharges from agricultural lands in the San Joaquin River basin to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan)	1	SJR-1.9	SRCS, STE	SWRCB	1,5	5 Years	TBD	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
are met for all potential pollutants.												
Complete Total Maximum Daily Load projects for all Clean Water Act Section 303(d) listed pollutants entering the San Joaquin River.	1	SJR-1.10	SRCS, STE	SWRCB	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop and implement a spawning gravel augmentation plan in the San Joaquin River.	1	SJR-1.11	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1	Long-term	$0	$0	$0	$0	$0	$0; covered under San Joaquin River Restoration Program
Develop and implement a program to reestablish steelhead upstream of Friant Dam. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot phase prior to implementation of the long-term program.	2	SJR-2.1	STE	NMFS, USFWS, USBR, CDFW, DWR	1,5	Long-term	$200,000	$4,000,000	$15,000,000	$17,000,000	$14,000,000	$50,200,000
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in the San Joaquin River.	2	SJR-2.2	SRCS, STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, CDFW, DWR, SWRCB, Landowners	1,5	Long-term	$62,400	$0	$0	$0	$0	$62,400

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop education and outreach programs and coordinate with local governments, communities, and conservation districts to encourage river stewardship in the San Joaquin River basin.	2	SJR-2.3	SRCS, STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, CDFW, DWR, SWRCB	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000
Permanently protect San Joaquin River riparian and floodplain habitat through easements and/or land acquisition.	2	SJR-2.4	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,5	Long-term	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Implement projects to protect and restore riparian and floodplain habitats along the San Joaquin River, such as projects underway at the San Joaquin River National Wildlife Refuge to restore riparian habitat, expand the refuge, and breach deauthorized levees in order to increase floodplain habitat.	2	SJR-2.5	SRCS, STE		1,4	Long-term	TBD based on type and amount of habitat restored; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on type and amount of habitat restored; initial study is expected to cost at least $50,000.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Coordinate with county and other local planning processes to encourage protection of floodplain habitat along the San Joaquin River.	2	SJR-2.6	SRCS, STE	NMFS, USFWS, Corps, CDFW, DWR, Local governments	1,5	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement of illegal stream bank alterations and monitor permitted alterations in the San Joaquin River.	2	SJR-2.7	SRCS, STE	Corps, SWRCB	1,4	Long-term						Cost is covered under action # COC-2.9
Compile available data and/or conduct new habitat analyses to determine if instream cover is lacking in the San Joaquin River, and add instream cover as necessary.	2	SJR-2.8	SRCS, STE	NMFS, USFWS, CDFW	1	5 years	$0	$0	$0	$0	$0	$0
Implement studies designed to quantify the impact of predation on steelhead in the San Joaquin River and identify specific locations where predation is a problem.	2	SJR-2.9	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,3,4	5 Years	$200,000-$400,000	$0	$0	$0	$0	$200,000-$400,000
Conduct studies to evaluate whether predator control actions (e.g., fishery management or directed removal programs) can be effective at minimizing predation on steelhead and spring-run Chinook salmon in the San Joaquin River; continue implementation if effective.	2	SJR-2.10	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR	1,3,4	5 Years						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement habitat enhancement or augmentation actions designed to minimize predation on steelhead in the San Joaquin River.	2	SJR-2.11	SRCS, STE	NMFS, USFWS, USBR, CDFW, DWR, Various NGOs	1,3,4	Long-term	$0	$0	$0	$0	$0	$0
Develop and implement design criteria and projects to minimize predation at weirs, diversion dams, and related structures in the San Joaquin River.	2	SJR-2.12	SRCS, STE	NMFS, USFWS, USBR, Corps, CDFW, DWR	1,3,5	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												$38,000 annually (BDCP 2013).
Monitor and evaluate the sport fishing regulations for the San Joaquin River to ensure they are consistent with the recovery of steelhead and spring-run Chinook salmon, and work with the Fish and Game Commission to modify the regulations as needed.	2	SJR-2.13	SRCS, STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0
Develop information to better understand the interaction between surface water and groundwater in the San Joaquin watershed in order to evaluate the potential impacts of water management options (e.g., groundwater sales; conjunctive use) in the watershed on San Joaquin River flows.	2	SJR-2.14	SRCS, STE	SWRCB, DWR, NMFS, USFWS, USBR, Corps, CDFW,	1.4	Short-term	$0	$0	$0	$0	$0	$0
Develop information to better understand the potential impact of inter basin water management (i.e., Sacramento River water being pumped into and then running off the San Joaquin basin) on the migratory cues and fish response (e.g., straying) for returning adult Chinook salmon and	2	SJR-2.15	SRCS, STE	NMFS, USFWS, USBR, Corps, CDFW, DWR	1,4	Short-term	$5,000 for initial study to develop goals, objectives, experimental design, and statistical analysis; cost of the research and monitoring is TBD based on the initial	TBD	$0	$0	$0	$5,000 for initial study to develop goals, objectives, experimental design, and statistical analysis; cost of the research and monitoring is TBD based on the initial study.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
steelhead.							study.					
Develop an incentive-based entrainment monitoring program in the San Joaquin River designed to work cooperatively with diverters to develop projects or actions in order to minimize pumping impacts.	2	SJR-2.16	SRCS, STE	NMFS, USFWS, USBR, Corps, CDFW, DWR	1,4	Short-term	TBD based on number of diversions and site specific factors affecting screening costs. Entrainment monitoring program estimated at up to $300,000 annually.	TBD	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).

5.10 Southern Sierra Nevada Diversity Group Recovery Actions

5.10.1 Merced River Recovery Actions

Table 5-26. Merced River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement a program to reestablish steelhead in historic habitat upstream of Crocker-Huffman, Merced Falls, McSwain, and New Exchequer dams. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term program.	1	MER-1.1	STE	NMFS, USFWS, USBR, CDFW, DWR, MID, PG&E, FERC	1,5	Long-term	$200,000	$4,000,000	$15,000,000	$17,000,000	$14,000,000	$50,200,000
Manage releases from New Exchequer Reservoir in order to provide the	2	MER-1.2	STE	NMFS, USFWS, MID, FERC, CDFW, DWR	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in the FERC licensing process

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
most beneficial flow and water temperatures for all steelhead life stages.												
Supplement flows provided pursuant to the Davis-Grunsky Contract and FERC License Number 2179 with water acquired from willing land owners and water districts to provide additional instream flow.	1	MER-1.3	STE	NMFS, USFWS, USBR, CDFW, DWR	1,4	Long-term	$0	$0	$0	$0	$0	$0
Develop a Merced River steelhead team to help guide collection and evaluation of baseline data to help address hypotheses for why resident O.mykiss are more abundant than anadromous O.mykiss in the Merced River. This information could be used to identify the flow and water	1	MER-1.4	STE	NMFS, USFWS, CDFW, DWR	1,2,3,4,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
temperature conditions that are most beneficial to anadromous O. mykiss.												
Evaluate whether pulse flows in the Merced River are beneficial to adult steelhead immigration and juvenile steelhead emigration; if pulse flows are determined to be effective, implement the most beneficial pulse flow regime.	1	MER-1.5	STE	NMFS, USFWS, MID, FERC, CDFW, DWR	1,4	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in the FERC licensing process
Identify and implement floodplain and side channel projects to improve river function and increase habitat diversity in the Merced River.	1	MER-1.6	STE	NMFS, USFWS, MID, FERC, CDFW, DWR	1,4,5	Short-term	TBD, based on amount of floodplain and side channel habitat restored. Floodplain restoration unit cost ranges from is $5,000 - $80,000/acre (Appendix D Table HI-4); side channel reconnection unit cost ranges from $20,000 to	TBD	$0	$0	$0	TBD, based on amount of floodplain and side channel habitat restored. Floodplain restoration unit cost ranges from is $5,000 - $80,000/acre (Appendix D Table HI-4); side channel reconnection unit cost ranges from $20,000 to $300,000/acre.. $5,000-$50,000 for initial scoping evaluation.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
							$300,000/acre.. $5,000-$50,000 for initial scoping evaluation.					
Develop and implement a long-term gravel management plan to increase and maintain steelhead spawning habitat downstream of Crocker-Huffman, Merced Falls, and New Exchequer dams.	1	MER-1.7	STE	NMFS, USFWS, , MID, PG&E, FERC, CDFW, DWR	1,4	Long-term	$50,000 for plan development; gravel augmentation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD
Prioritize Merced River diversions based on their level of entrainment and screen those with the highest benefit to cost ratio.	2	MER-2.1	STE	NMFS, USFWS, USBR, CDFW, DWR, MID	1,3,5	5 years	$50,000 for prioritization; screening costs are TBD.	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).
Work with water rights holders in the Merced River watershed to provide flows that are	2	MER-2.2	STE	NMFS, USFWS, USBR, Corps, CDFW, DWR, NRCS, Family Water Alliance, MID	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
protective of steelhead.												
Develop and implement ramping rate criteria for the Merced River that are protective of anadromous fishes.	2	MER-2.3	STE	NMFS, USFWS, Corps, MID, PG&E, FERC, CDFW, DWR	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in the FERC licensing process
Continue to supply spawning-sized gravel to landowners for construction and maintenance of wing dam diversion structures in the Merced River; implement the Gravel Mining Reach Phase II projects.	2	MER-2.4	STE	NMFS, USFWS, CDFW, DWR	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD based on amount of gravel added; Per unit cost is $11 to $72/cubic yard (Appendix D).
Evaluate the potential benefits and feasibility of installing a water temperature control device on New Exchequer Dam in order to most efficiently	2	MER-2.5	STE	NMFS, USFWS, USBR, MID, FERC, CDFW, DWR	1	Short-term	<$50,000	$0	$0	$0	$0	<$50,000 for evaluation and feasibility study.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
utilize the volume of cold water in the reservoir.												
Federal, State, and local agencies should use their authorities to develop and implement programs and projects that focus on retaining, restoring and creating riparian corridors within their jurisdiction in the Merced River watershed.	2	MER-2.6	STE	USFWS, Corps, CDFW, DWR, Local agencies, NGOs	1,4	Long-term	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$30,000 - $135,000	$150,000 -$675000
Permanently protect Merced River riparian habitat through easements and/or land acquisition	2	MER-2.7	STE	NMFS, USFWS, CDFW, DWR, landowners, Resource Conservation Districts	1,5	Long-term	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Increase monitoring and enforcement of illegal rip rap applications in the Merced	2	MER-2.8	STE	Corps, SWRCB	1,4,5	Long-term						Cost is covered under action # COC-2.9

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
River.												
Implement studies designed to quantify the impact of predation on steelhead in the Merced River. If the studies identify predator species and/or locations contributing to low steelhead survival, then evaluate whether predator control actions (e.g., fishery management or directed removal programs) can be effective at minimizing predation on steelhead in the Merced River; continue implementation if effective.	2	MER-2.9	STE	NMFS, USFWS, CDFW, DWR	1,2,3	Long-term						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement programs and measures designed to control predation in the Merced River, including actions to isolate “ponded” sections of the river.	2	MER-2.10	STE	NMFS, USFWS, CDFW, DWR	1,3,5	Long-term	$0	$0	$0	$0	$0	$0

5.10.2 Tuolumne River Recovery Actions

Table 5-27. Tuolumne River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Evaluate and, if feasible, develop and implement a steelhead and spring-run Chinook salmon passage program for La Grange and Don Pedro dams. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term reintroduction program.	1	TUR-1.1	STE	NMFS, CDFW, Modesto Irrigation District, Turlock Irrigation District, FERC	1,5	Long-term	$720,150	$9,000,000	$3,468,000	$0	$0	$13,188,150

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Manage releases from La Grange and Don Pedro dams to provide suitable flows and water temperatures for all downstream life stages of steelhead.	1	TUR-1.2	STE	NMFS, CDFW, Modesto Irrigation District, Turlock Irrigation District, FERC	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in the FERC licensing process
Develop a Tuolumne River steelhead team to help guide collection and evaluation of baseline data to help address hypotheses for why resident O.mykiss are more abundant than anadromous O.mykiss in the Tuolumne River. This information could be used to identify the flow and water temperature conditions that are most	1	TUR-1.3	STE	USFWS, CDFW, NMFS	1	Short-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
beneficial to anadromous O. mykiss.												
Evaluate whether pulse flows in the Tuolumne River are beneficial to adult steelhead immigration and juvenile steelhead emigration; if pulse flows are determined to be effective, implement the most beneficial pulse flow regime.	1	TUR-2.1	STE	NMFS, USFWS, USBR, CDFW, DWR, Modesto and Turlock Irrigation Districts, FERC	1	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in the FERC licensing process
Continue to implement projects to increase the availability and quality of spawning and rearing habitat in the Tuolumne	2	TUR-2.2	STE	NMFS, USFWS, USBR, CDFW, DWR, Modesto and Turlock Irrigation Districts	1,4	Long-term	TBD	TBD	TBD	TBD	TBD	TBD based on the amount of spawning gravel to be added and the type and amount of rearing habitat restored. Per unit cost for gravel augmentation is $11 to $72/cubic yard (Appendix D). See Appendix D for per unit costs of restoring various

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
River.												types of rearing habitats (e.g., riparian, floodplain, instream cover. $5,000-$50,000 for initial scoping of rearing habitat restoration opportunities and gravel needs.)
Evaluate the feasibility of moving water diversions lower in the Tuolumne River in order to provide higher flows in the upstream reaches. If feasible and cost effective, move water diversions lower in the Tuolumne River.	2	TUR-2.3	STE	NMFS, USFWS, USBR, CDFW, DWR, Modesto and Turlock Irrigation Districts	1	Long-term	<$200,000 for evaluation; cost of moving diversions TBD based on information obtained during the evaluation.	TBD	TBD	TBD	TBD	<$200,000 for evaluation; cost of moving diversions TBD based on information obtained during the evaluation.
Develop and implement flow fluctuation criteria for the Tuolumne River that are protective of anadromous	2	TUR - 2.4	STE	NMFS, USFWS, Corps, CDFW, DWR, Modesto and Turlock Irrigation Districts, FERC	1	Long-term	TBD	TBD	TBD	TBD	TBD	TBD in the FERC licensing process

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
fishes.												
Work with State and Federal water acquisition programs to dedicate instream water in the Tuolumne River.	2	TUR - 2.5	STE	NMFS, USFWS, USBR, CDFW, DWR, Modesto and Turlock Irrigation Districts	1	Long-term	$0	$0	$0	$0	$0	$0
Evaluate modifying current operation plans (e.g., flood control curves) for Don Pedro with the Corps and irrigation districts to reallocate instream flows for salmonids.	2	TUR - 2.6	STE	Corps, Modesto and Turlock Irrigation Districts, NMFS, USFWS, CDFW	1	Short-term	$0	$0	$0	$0	$0	$0
Identify and implement floodplain and side channel projects to improve river function and	2	TUR - 2.7	STE	NMFS, USFWS, CDFW, Modesto and Turlock Irrigation Districts	1	Short-term	TBD	TBD	$0	$0	$0	TBD, based on amount of floodplain and side channel habitat restored. Floodplain restoration unit cost ranges from is $5,000 - $80,000/acre (Appendix D Table HI-

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
increase habitat diversity in the Tuolumne River.												4); side channel reconnection unit cost ranges from $20,000 to $300,000/acre. $5,000-$50,000 for initial scoping of restoration opportunities.
Update the 2006 Water Quality Control Plan for the Bay-Delta in order to improve flow conditions for steelhead in the Tuolumne River.	2	TUR - 2.8	STE	SWRCB, CDFW, USFWS, NMFS, Modesto and Turlock Irrigation Districts	1,4	Long-term	$0	$0	$0	$0	$0	$0
Restore riparian habitat to promote shading and habitat diversity in the Tuolumne River.	2	TUR - 2.9	STE	Corps, Modesto and Turlock Irrigation Districts, NMFS, USFWS, CDFW, CV Flood Protection Board	1		TBD	TBD	TBD	TBD	TBD	TBD, based on amount of habitat restored. As identified in Appendix D, per unit costs vary depending on whether fencing, planting, irrigation, or invasive weed control are needed. $5,000-$50,000 for initial scoping of restoration opportunities.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Implement projects to minimize predation at weirs, diversion dams, and related structures in the Tuolumne River.	2	TUR - 2.10	STE	NMFS, CDFW, DWR, USFWS, Modesto and Turlock Irrigation Districts	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about $38,000 annually (BDCP 2013).
Improve instream refuge cover for salmonids in the Tuolumne River to minimize predatory opportunities for striped bass and other non-native	2	TUR - 2.11	STE	NMFS, USFWS, CDFW, DWR	1,3	Long-term	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and placement method. Initial scoping to address those	TBD	TBD	TBD	TBD	TBD, based on the # of sites, amount of material needed, type of material, location of source material (onsite vs. imported), and placement method. Cost of initial study to address these issues is $5,000-$50,000. See Table H1-2 in Appendix D for cost per unit for various

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
predators.							issues would cost at least $50,000. See Table H1-2 in Appendix D for cost per unit for various projects.					projects
Develop a baseline monitoring program for the Tuolumne River to evaluate water quality throughout the watershed to identify pollutants to be included on the Clean Water Act section 303(d) list.	2	TUR - 2.12	STE	SWRCB, CDFW, USFWS, NMFS, Modesto and Turlock Irrigation Districts	1,5	Short-term	$0	$0	$0	$0	$0	$0
Complete Total Maximum Daily Load projects for all Clean Water Act Section 303(d) listed pollutants entering the Tuolumne	2	TUR - 2.13	STE	SWRCB	1	Short-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
River.												
Encourage voluntary landowner participation in the Tuolumne River watershed in educational opportunities such as water quality short courses, field demonstrations and distribution of water quality "Fact Sheets".	2	TUR - 2.14	STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, CDFW, DWR, Landowners	2	Long-term	$76,140	$76,140	$76,140	$76,140	$0	$304,560
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in the Tuolumne River.	2	TUR - 2.15	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, CDFW, DWR, SWRCB	1,5	Long-term	$62,400	$0	$0	$0	$0	$62,400

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Increase monitoring and enforcement in the Tuolumne River to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants excluding water temperature.	2	TUR - 2.16	STE	SWRCB, CVRWQCB, Local agriculture groups	1,4	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)
Evaluate Tuolumne River O.mykiss genetics to inform management in the anadromous reach as well as planning for potential reintroductions to the upper river.	3	TUR - 3.1	STE	CDFW, USFWS, NMFS	1,5	Short-term	$25,000 - $50,000	$0	$0	$0	$0	$25,000 - $50,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Prioritize lower Tuolumne River diversions based on their level of entrainment and screen those with the highest benefit to cost ratio	3	TUR - 3.2	STE	CDFW, USFWS, NMFS, USBR, DWR, Modesto and Turlock Irrigation Districts	1,5	5 years	$50,000 for prioritization; screening costs are TBD.	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).

5.10.3 Stanislaus River Recovery Actions

Table 5-28. Stanislaus River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Evaluate and, if feasible, develop and implement a steelhead passage program for Tullock, Goodwin, and New Melones dams. The program should include feasibility studies, habitat evaluations, fish passage design studies, and a pilot reintroduction phase prior to implementation of the long-term reintroduction program.	1	STR-1.1	STE	NMFS, USFWS, USBR, CDFW, OID, South San Joaquin Irrigation District, TriDam, PG&E, FERC	1,5	Long-term	$720,150	$9,000,000	$3,468,000	$0	$0	$13,188,150

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Manage releases from Tulloch, Goodwin, and New Melones dams to provide suitable water temperatures and flows for all steelhead life stages. Suitable water temperatures for the Stanislaus River are specified on page 621 of the biological opinion for the long-term operations of the CVP/SWP (NMFS 2009b). Suitable minimum instream flow schedules for the Stanislaus River are described in Appendix 2-E of the biological opinion	1	STR-1.2	STE	NMFS, USFWS, USBR, Corps, CDFW, DWR, OID, South San Joaquin Irrigation District, Tridam	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
(NMFS 2009b).												
Develop a Stanislaus River steelhead team to help guide collection and evaluation of baseline data to help address hypotheses for why resident O.mykiss are more abundant than anadromous O.mykiss in the Stanislaus River. This information could be used to identify the flow and water temperature conditions that are most beneficial to anadromous O. mykiss.	1	STR-1.3	STE	NMFS, USFWS, USBR, CDFW	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Continue to implement projects to increase the availability and quality of spawning and rearing habitat in the Stanislaus River.	2	STR-2.1	STE	NMFS, USFWS, USBR, CDFW, DWR	1,4	Long-term	$0	$0	$0	$0	$0	$0
Evaluate whether pulse flows in the Stanislaus River are beneficial to adult steelhead immigration and juvenile steelhead emigration; if pulse flows are determined to be effective, implement the most beneficial pulse flow regime.	2	STR-2.2	STE	NMFS, USFWS, USBR, CDFW, DWR, Stanislaus River Fish Group, OID, South San Joaquin Irrigation District, TriDam, PG&E, FERC	1,5	Long-term	$0	$0	$0	$0	$0	$0. Pulse flows are required under the 2009 biological opinion for the long-term operations of the CVP/SWP.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Work with State and Federal water acquisition programs to dedicate instream water in the Stanislaus River.	2	STR-2.3	STE	NMFS, USFWS, USBR, CDFW, DWR, Stanislaus River Fish Group	1	Long-term	$0	$0	$0	$0	$0	$0
Negotiate agreements with landowners, water districts, and Federal and State agencies to provide additional instream flows or purchase water rights in the Stanislaus River.	2	STR-2.4	STE	NMFS, USFWS, USBR, Corps, Resource Conservation Districts, CDFW, DWR, Water districts, Landowners, Local governments, NGOs	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water. Cost per unit is $162 - $246/af/year for south of Delta water purchases (Appendix D)
Utilize the SWRCB regulatory process of updating the 2006 Water Quality Control Plan for the Bay-Delta to	2	STR-2.5	STE	NMFS, SWRCB	1,4	Short-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
improve flow conditions for steelhead in the Stanislaus River.												
Identify and implement floodplain and side channel projects to improve river function and increase habitat diversity in the Stanislaus River.	2	STR-2.6	STE	NMFS, USFWS, USBR, Corps, CDFW, DWR	1	Short-term	TBD, based on amount of floodplain and side channel habitat restored. Floodplain restoration unit cost ranges from is $5,000 - $80,000/acre (Appendix D Table HI-4); side channel reconnection unit cost ranges from $20,000 to $300,000/acre.. $5,000-$50,000 for initial scoping evaluation.	TBD	$0	$0	$0	TBD, based on amount of floodplain and side channel habitat restored. Floodplain restoration unit cost ranges from is $5,000 - $80,000/acre (Appendix D Table HI-4); side channel reconnection unit cost ranges from $20,000 to $300,000/acre.. $5,000-$50,000 for initial scoping evaluation.
Work with local land owners to restore riparian habitats along the Stanislaus River.	2	STR-2.7	STE	NMFS, USFWS, USBR, CDFW, DWR, Stanislaus River Fish Group	1,5	Long-term	TBD, based on amount of floodplain and side channel habitat restored. Floodplain restoration unit cost ranges from is $5,000 - $80,000/acre	TBD	$0	$0	$0	TBD, based on amount of floodplain and side channel habitat restored. Floodplain restoration unit cost ranges from is $5,000 - $80,000/acre (Appendix D Table

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
							(Appendix D Table HI-4); side channel reconnection unit cost ranges from $20,000 to $300,000/acre.. $5,000-$50,000 for initial scoping evaluation.					HI-4); side channel reconnection unit cost ranges from $20,000 to $300,000/acre.. $5,000-$50,000 for initial scoping evaluation.
Permanently protect riparian habitat along the Stanislaus River through easements and/or land acquisition.	2	STR-2.8	STE	NMFS, USFWS, USBR, Corps, Resource Conservation Districts, CDFW, DWR, Water districts, Landowners, Local governments, NGOs	1,5	Long-term	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD, based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Monitor and evaluate the impact of the sport fishery on Stanislaus River steelhead to ensure the regulations are consistent with steelhead recovery, and work with the Fish and Game Commission to	2	STR-2.9	STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
modify the regulations as needed.												
Increase monitoring and enforcement in order to minimize steelhead poaching in the Stanislaus River.	2	STR-2.10	STE	NMFS, CDFW	2,4	Long-term						Cost is covered under action # COC-2.9
Implement outreach projects in the Stanislaus River to educate the public regarding the steelhead life cycle including how to identify steelhead redds. Encourage voluntary landowner participation in the Stanislaus River in educational opportunities such as water	2	STR-2.11	STE	NMFS, USFWS, USBR, CDFW, DWR, Stanislaus River Fish Group	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
quality short courses, field demonstrations and distribution of water quality "Fact Sheets".												
Evaluate programs and measures designed to minimize predation in the Stanislaus River.	2	STR-2.12	STE	NMFS, USFWS, CDFW, DWR, Stanislaus River Fish Group, OID	1,3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost about

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												$38,000 annually (BDCP 2013).
Implement projects to minimize predation in the Stanislaus River at mine pits and at deep pools caused by bank stabilization projects.	2	STR-2.13	STE	NMFS, USFWS, CDFW, DWR, Stanislaus River Fish Group	1,3,4	Long-term	Costs covered in action STR-2.12	Costs covered in action STR-2.12	Costs covered in action STR-2.12	Costs covered in action STR-2.12	Costs covered in action STR-2.12	Costs covered in action STR-2.12
Implement projects to increase instream habitat complexity and predator refuge cover in the Stanislaus River, including the addition of large woody material.	2	STR-2.14	STE	NMFS, USFWS, CDFW, DWR, Stanislaus River Fish Group	1,3,4	Long-term	$750,000 - $2,000,000	$750,000 - $2,000,000	$750,000 - $2,000,000	$750,000 - $2,000,000	$750,000 - $2,000,000	$3,750,000 - $10,000,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop a baseline monitoring program for the Stanislaus River to evaluate water quality throughout the watershed to identify areas of concern.	2	STR-2.15	STE	NMFS, USWFS, USEPA, Resource Conservation Districts, CDFW, DWR, SWRCB, Stanislaus River Fish Group	1,5	3 Years	$0	$0	$0	$0	$0	$0
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water quality impacts in the Stanislaus River.	2	STR-2.16	STE	NMFS, USFWS, USFS, USEPA, Resource Conservation Districts, CDFW, DWR, Landowners	1,5	Long-term	$62,400	$0	$0	$0	$0	$62,400
Increase monitoring and enforcement in the Stanislaus River to ensure that the water quality criteria	2	STR-2.17	STE	SWRCB, CVRWQCB, Local agriculture groups	1,4,5	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants.												
Complete Total Maximum Daily Load projects for all Clean Water Act Section 303(d) listed pollutants entering the Stanislaus River.	2	STR-2.18	STE	EPA, SWRCB, CVRWQCB, Local agriculture groups	1,5	Long-term	$0	$0	$0	$0	$0	$0
Evaluate Stanislaus River *O.mykiss* genetics to inform management in the anadromous reach as well as planning for potential reintroductions to the upper river.	2	STR-2.19	STE	NMFS, CDFW, Reclamation, USFWS	1,5	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop an entrainment monitoring program in the Stanislaus River to determine the level of take at individual diversions. Prioritize diversions based on this monitoring program and screen those that are determined to have substantial impacts.	3	STR-3.1	STE	NMFS, USFWS, CDFW	1,3,5	5 years	$100,000 for monitoring program; screening costs are TBD.	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is estimated at $20 million (San Francisco Estuary Partnership 2007).

5.10.4 Calaveras River Recovery Actions

Table 5-29. Calaveras River Recovery Actions.

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Develop and implement long-term year-round instream flow schedules and water temperature requirements that are protective of all steelhead life stages, including providing flows for upstream and downstream fish passage.	1	CAR - 1.1	STE	NMFS, USFWS, CDFW	1	Long-term	$594,090	$0	$0	$0	$0	$594,090
Establish a minimum carryover storage level at New Hogan Reservoir that meets the instream flow and water temperature requirements in the lower Calaveras River.	1	CAR - 1.2	STE	NMFS, USFWS, CDFW, Corps	1,5	Long-term	$1,144,240	$0	$0	$0	$0	$1,144,240
Remove or modify all fish passage impediments in the lower Calaveras River to meet NMFS and CDFW fish passage criteria.	1	CAR - 1.3	STE	NMFS, USFWS, CDFW, Corps	1	Long-term	$0	$15,000,000	$0	$0	$0	$15,000,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Monitor upstream and downstream fish passage through the existing Bellota weir fish ladder and operate the weir based on this monitoring information to provide timely and safe fish passage.	1	CAR-1.4	STE	NMFS, USFWS, USBR, CDFW, DWR, Fishery Foundation of California, Stockton East Water District	1,4	Long-term	$0	$0	$0	$0	$0	$0
Replace Bellota weir incorporating a permanent fish ladder and screened diversion as recommended in the Calaveras River Fish Screen Facilities Feasibility Study.	1	CAR-1.5	STE	NMFS, USFWS, USBR, CDFW, DWR, Fishery Foundation of California, Stockton East Water District	1	Short-term	$8-$10 million	$0	$0	$0	$0	$8-$10 million
Implement a Calaveras River monitoring program to identify the temporal and spatial distributions of migrating and holding steelhead. These data would help ensure that suitable flows, water temperatures, and passage conditions are	1	CAR-1.6	STE	NMFS, USFWS, USBR, CDFW, DWR, Fishery Foundation of California, Stockton East Water District	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
being provided when and where the fish are in the Calaveras River.												
Fully implement the Calaveras River fish passage improvement project in order to provide permanent upstream and downstream passage for salmonids between the mouth of the Calaveras River and Bellota weir.	2	CAR-2.1	STE	DWR, USFWS, USBR, Corps, CDFW, Fishery Foundation of California, Stockton East Water District	1	Long-term	TBD	TBD	TBD	TBD	TBD	TBD based on the number and type of fish passage impediments. NMFS is in the process of obtaining a cost estimate from DWR, the lead agency for the project.
Until year-round permanent fish passage improvements are made to preclude the need for flashboard weirs, operate Bellota and other weirs so that the flashboards are not in place from at least October through June.	2	CAR-2.2	STE	USFWS, USBR, Corps, CDFW, DWR, Fishery Foundation of California, Stockton East Water District	1	Long-term	$0	$0	$0	$0	$0	$0
Prioritize and screen unscreened diversions in the Calaveras River including Bellota weir.	2	CAR-2.3	STE	CDFW, NMFS, Stockton East Water District, Calaveras County Water District	1,3,5	5 years	$50,000 for prioritization; screening costs are TBD.	$0	$0	$0	$0	The cost of installing screens on all diversions in the Sacramento and San Joaquin river systems is

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												estimated at $20 million (San Francisco Estuary Partnership 2007).
Negotiate agreements with landowners, Stockton East Water District (SEWD), Calaveras County Water District (CCWD) and federal and state agencies to provide additional instream flows.	2	CAR-2.4	STE	SEWD, CCWD, NMFS, USFWS, Corps, USBR, Resource Conservation Districts, CDFW, DWR, Water Districts, Landowners, Local Governments, NGOs	1,5	Long-term	TBD	TBD	TBD	TBD	TBD	TBD, based on amount of water. Cost per unit is $162 - $246/af/year for south of Delta water purchases (Appendix D)
Purchase water rights from Calaveras River water diverters in order to increase flows.	2	CAR-2.5	STE	NMFS, USFWS, Corps, USBR, Resource Conservation Districts, CDFW, DWR, Water Districts, Landowners, Local Governments, NGOs	1,5	Short-term	TBD	TBD	$0	$0	$0	TBD based on the amount of water accounted for in the water right. Cost per unit is $162 - $246/af/year for south of Delta water purchases (Appendix D)
Continue implementing the recommendations from the lower Calaveras River Salmonid Life History Limiting Factor Analysis to assess flow requirements for anadromous salmonids and also develop and implement further specific	2	CAR-2.6	STE	NMFS, USFWS, USBR, CDFW, DWR, Stockton East Water District	1	Long-term	$0	$0	$0	$0	$0	$0

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
recommendations.												
Evaluate pulse flow benefits for steelhead attraction and passage in the Calaveras River; if pulse flows are determined to be effective for attracting steelhead, implement the most beneficial pulse flow regime.	2	CAR-2.7	STE	NMFS, USFWS, USBR, Corps, DWR, CDFW	1,5	Long-term	$0	$0	$0	$0	$0	$0
Develop a baseline monitoring program for the Calaveras River to evaluate water quality throughout the watershed to identify areas of concern.	2	CAR-2.8	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW	1	3 Years	$0	$0	$0	$0	$0	$0
Pursue grant funding or cost-share payments for landowners to inventory, prepare plans and implement best-management practices that reduce water	2	CAR-2.9	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW	1	Long-term	$62,400	$0	$0	$0	$0	$62,400

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
quality impacts in the Calaveras River.												
Increase monitoring and enforcement in the Calaveras River to ensure that the water quality criteria established in the Central Valley Water Quality Control Plan (Basin Plan) are met for all potential pollutants.	2	CAR-2.10	STE	SWRCB, CVRWQCB, Local agriculture groups	1,4	Long-term						Cost is covered under the cost of action SAR-2.6 ($1,750,000)
Complete Total Maximum Daily Load projects for all Clean Water Act Section 303(d) listed pollutants entering the Calaveras River.	2	CAR-2.11	STE	NMFS, USFWS, USEPA, Resource Conservation Districts, SWRCB, DWR, CDFW	1	Long-term	$0	$0	$0	$0	$0	$0
Develop and implement a spawning gravel augmentation plan in the Calaveras River, including periodic evaluations of spawning gravel quality and quantity.	2	CAR-2.12	STE	NMFS, USFWS, Corps, DWR, CDFW	1	Long-term	$50,000 for plan development; gravel augmentation costs TBD	TBD	TBD	TBD	TBD	$50,000-TBD

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Curtail further development in active Calaveras River floodplains through zoning restrictions, county master plans, and other Federal, State, and county planning and regulatory processes.	2	CAR-2.13	STE	NMFS, USFWS, Corps, CDFW, DWR, Local governments	1,5	Long-term	$0	$0	$0	$0	$0	$0
Utilize bio-technical techniques that integrate riparian restoration for river bank stabilization instead of conventional rip rap in the Calaveras River.	2	CAR-2.14	STE	NMFS, USFWS, USBR, Corps, CDFW, DWR, CBDA	1	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement of illegal stream bank alterations and monitor permitted alterations in the Calaveras River.	2	CAR-2.15	STE	Corps, SWRCB	1,4	Long-term						Cost is covered under action # COC-2.9
Develop education and outreach programs to encourage river stewardship in the Calaveras River.	2	CAR-2.16	STE	NMFS, USFWS, USBR, CDFW, DWR, Various NGOs	2	Long-term	$75,000	$75,000	$75,000	$75,000	$75,000	$375,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
Monitor and evaluate the sport fishing regulations for the Calaveras River to ensure they are consistent with the recovery of steelhead, and work with the Fish and Game Commission to modify the regulations as needed.	2	CAR-2.17	STE	NMFS, CDFW	2	Long-term	$0	$0	$0	$0	$0	$0
Increase monitoring and enforcement in order to minimize anadromous fish poaching in the Calaveras River.	2	CAR-2.18	STE	CDFW	2	Long-term						Cost is covered under action # COC-2.9
Implement a study designed to quantify the amount of predation on steelhead by non-native species in the Calaveras River. If the study identifies predator species and/or locations contributing to low steelhead survival, then evaluate whether predator control actions (e.g., fishery management or	2	CAR-2.19	STE	NMFS, USFWS, CDFW, DWR	1,2	Long-term						Cost covered by the cost of SFB-2.5 ($0-$75,000,000).

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
directed removal programs) can be effective at minimizing predation on juvenile steelhead in the Calaveras River; continue implementation if effective.												
Develop and implement design criteria and projects to minimize predation at weirs, diversion dams, and related structures in the in the Calaveras River.	2	CAR-2.20	STE	NMFS, CDFW, DWR, USFWS, USBR, Corps	3	Long-term	$5,000-$50,000 for site identification and evaluation; project implementation costs TBD. See total cost for potential site-specific costs.	TBD	TBD	TBD	TBD	$5,000-$50,000 for site identification and evaluation. Total cost TBD. If structural modification is identified as a solution at a particular site, it is impracticable to provide a cost without knowing details of the specific structure and what type of modification is needed. If structural removal is identified as a solution, it is assumed that the average cost of removal will be roughly $8,300 per structure (BDCP 2013). If predator removal is identified as a solution, it is assumed that each site will cost

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
												about $38,000 annually (BDCP 2013).
Improve refuge cover for steelhead in the Calaveras River to minimize predatory opportunities for predators.	2	CAR-2.21	STE	NMFS, USFWS, CDFW, DWR	1,2	Short-term	TBD, based on the # of sites, # of miles, type of material, location of source material (onsite vs. imported), and placement method. See Table H1-2 in Appendix D for cost per unit for various projects.	$0	$0	$0	$0	TBD, based on the # of sites, amount of material needed, type of material, location of source material (onsite vs. imported), and placement method. Cost of initial study to address these issues is $5,000-$50,000. See Table H1-2 in Appendix D for cost per unit for various projects
Permanently protect riparian habitat through easements and/or land acquisition.	2	CAR-2.22	STE	NMFS, USFWS, CDFW, DWR	1,5	Long-term	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.	TBD	TBD	TBD	TBD	TBD based on specific easements and land acquisitions; initial study is expected to cost at least $50,000.
Examine the potential for re-establishing steelhead in historic habitats upstream of New Hogan Dam by conducting feasibility and habitat evaluations. If	3	CAR-3.1	STE	NMFS, USFWS, CDFW, DWR, Corps	1,5	Long-term	$200,000	$4,000,000	$15,000,000	$17,000,000	$14,000,000	$50,200,000

Recovery Action	Action Priority	Action ID	Species	Potential Collaborators	Listing Factor(s) Addressed	Duration	~ Cost FY1-5	~ Cost FY6-10	~ Cost FY11-15	~ Cost FY16-20	~ Cost FY21-25	Total ~Cost
these evaluations suggest that re-establishment can be successful, then develop a phased program intended to re-establish steelhead upstream of New Hogan Dam.												

6.0 Climate Change and Recovery of Salmon and Steelhead

"Climate variability plays a large role in driving fluctuations in salmon abundance by influencing their physical environment, the availability of food, the competitors for that food, and the predators that prey on small salmon. The complexity of influences on salmon, both climate and otherwise, combined with the scarcity of observations of factors important to salmon in estuaries and the ocean, make it challenging to identify the links between salmon and climate."

- Climate Impacts Group (2004)

6.1 Overview

The scientific basis for understanding the processes and sources of climate variability has grown significantly in recent years, and our ability to forecast human and natural contributions to climate change has improved dramatically. With consensus on the reality of climate change now established (Oreskes 2004; IPCC 2007), the scientific, political, and public priorities are evolving toward determining its ecosystem impacts, and developing strategies for adapting to those impacts. Climate forces directly influence regional temperature, wind, precipitation, snowpack and streamflow patterns, which may impact the habitat suitability for marine and anadromous species directly or indirectly (Schwing 2009).

Many salmon populations throughout the West Coast are at historically low levels due to stresses imposed by a variety of human activities including dam construction, logging, pollution, and over-fishing. Climate change affects salmon throughout their life cycle and poses an additional stress. Earlier peak flows flush young salmon from rivers to estuaries before they are physically mature enough for the transition, increasing a variety of stresses including the risk of being eaten by predators. Earlier snowmelt leaves rivers and streams warmer and shallower during the summer and fall (Thomas *et al*. 2009).

Increasing air temperatures, particularly during the summer, lead to rising water temperatures, which increase stress on coldwater fish such as salmon and steelhead. Projected temperatures for the 2020s and 2040s under a higher emissions scenario suggest that the habitat quality and quantity for these fish is likely to decrease dramatically (Mote *et al*. 2008; Salathé *et al*. 2005; Keleher *et al*. 1996; McCullough *et al*. 2001).

Warmer water temperatures and lower base flows will negatively affect salmonids in several ways. Fish metabolism increases with water temperature, reducing growth if more energy is devoted to searching for food. Warmer water causes salmonid eggs to hatch sooner. Resulting young may be smaller, and emerge at a time when their insect prey base is not available. (Thomas *et al*. 2009). In addition, diseases and parasites that infect salmon are more prevalent in warmer water.

Ocean conditions are also important to salmon populations, as they reside there for years. The oceans are also impacted by warmer temperatures. Warm coastal temperatures have been correlated with low salmon abundance; higher salmon abundance is associated with cooler ocean temperatures (Janetos *et al*. 2008; Crozier *et al*. 2008).

6.2 Climate Change and Environmental Variability

For ecosystem concerns (e.g., warming, wildfire, sea level rise, anthropogenic influences, El Niño) related to long-term climate changes, all regions under the management jurisdiction of NMFS are expected to experience environmental conditions that have not been experienced before. Warming over this century is projected to be considerably greater than over the last century (Thomas *et al*. 2009). Since 1900, the global average temperature has risen by about 1.5°F. By about 2100, it is projected to rise between 2°F and 10.5°F (**Figure 6-1**), but could increase up to 11.5°F (Thomas *et al*. 2009; California Climate Change Center 2006). In the United States, the average temperature has risen by a comparable amount and is very likely to rise more than the global average over this century, with some variation according to location. Several factors will determine future temperature increases. Increases at the lower end of this range are more likely if global heat-trapping gas emissions are substantially reduced.

If emissions continue to rise at or near current rates, temperature increases are more likely to be near the upper end of the range. Volcanic eruptions or other natural variations could temporarily counteract some of the human-induced warming, slowing the rise in global temperature, but these effects would only last a few years (Thomas *et al*. 2009).

Climate-related fire dynamics also will be affected by changes in the distribution of ecosystems across the landscape. Torn *et al*. (1998) project that there will be a doubling of catastrophic wildfires in some regions due to faster and more intense burning associated with warming, drying vegetation, and elevated wind speed. Increasing temperatures and shifting precipitation patterns also will drive declines in high elevation ecosystems such as alpine forests. As an example, under higher emissions scenarios (Figure 6-1), high-elevation forests in California are projected to decline by 60 to 90 percent before the end of the century. At the same time, grasslands are projected to expand, another factor likely to increase fire risk. Climate changes also could create subtle shifts in fire behavior, allowing more "runaway fires" – fires that are thought to have been brought under control, but then rekindle (Thomas *et al*. 2009).

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. A rise in sea level will most dramatically affect those estuaries that are confined by surrounding development, which prohibits their boundaries from naturally shifting in response to inundation. Projections for sea level rise by 2100 vary from 0.18 to 0.58

meters (m), to 0.5 to. 1.4 m (IPCC 2007a; 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 (NMFS 2009). A projected 1 m rise in sea level could potentially inundate 65 percent of the coastal marshlands and estuaries in the United States. In addition, there could 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. Regarding California's water supply, the largest effect of sea level rise would likely be in the Delta (DWR 2005c). Increased intrusion of salt water from the ocean into the Delta could lead to increased releases of water from upstream reservoirs or reduced pumping from the Delta to maintain compliance with Delta water quality standards (Anderson *et al*. 2008).

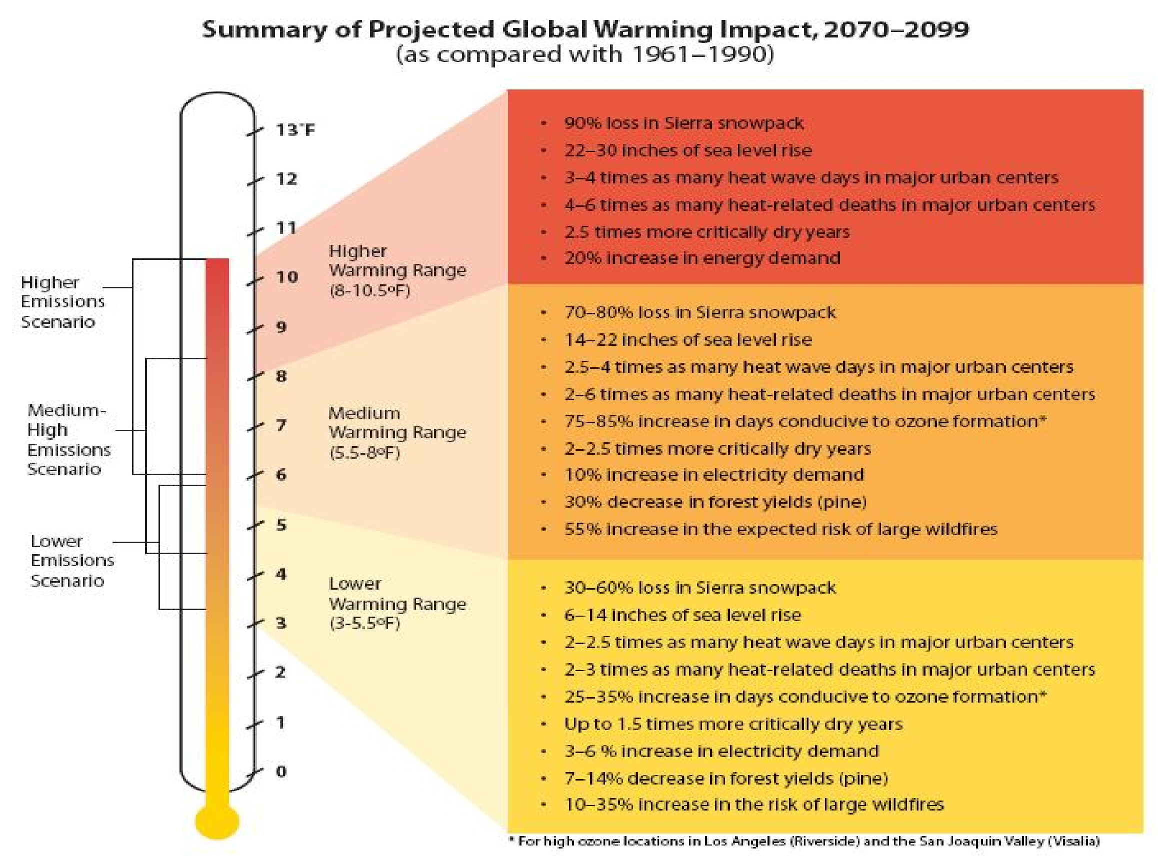

Figure 6-1. Summary of Projected Global Warming Impacts (2070 to 2099 compared to 1961 to 1990). ***(Source: California Climate Change Center 2006)***

Figure 6-2. Schematic of Coastal Upwelling Near the California Coast. Winds from the northwest during spring and summer drive surface water offshore, and it is replaced by cool water high in nutrients that is "upwelled" onto the continental shelf. ***(Source: NMFS 2009 - image from NOAA Cordell Bank National Marine Sanctuary).***

Anthropogenic influences on salmon and steelhead habitat play a primary role in climate influences on extinctions (Francis and Mantua 2003). Over the past 150 years, human activities have degraded, and in some cases completely eliminated, much of the historic stream and estuarine habitats for anadromous salmonids. In many ways, human actions have forced semi-permanent changes to the salmonid landscape that parallel those typically associated with climate change (Karr 1994). For example, stream temperatures, flow regimes, sediment transports, and pool-to-riffle ratios are all subject to anthropogenic and climate changes. Karr (1994) indicates that one major difference between perturbations due to natural climate events versus one caused by human activities is the time scale of the resulting impacts. A warm phase of the El Niño-Southern Oscillation generally impacts precipitation and flow over a single year, while hydropower dam construction alters flow for decades to centuries (Francis and Mantua 2003).

Because it affects the distribution of heat in the atmosphere and the oceans, climate change will affect winds and currents that move along the nation's coasts, such as the California Current that bathes the West Coast from British Columbia to Baja California (Thomas *et al*. 2009). Wind-driven upwelling of deeper ocean water along the coast in this area is vital to moderation of temperatures and the high productivity of Pacific Coast ecosystems (**Figure 6-2**). Warmer temperatures are likely to increase ocean stratification, yet possible increases in winds may counter that in ways that mitigate or even increase the wind-driven upwelling of nutrients that fuel a productive food web (CIG 2004).

Coastal currents are subject to periodic variations caused by the El Niño-Southern Oscillation and the Pacific Decadal Oscillation, which have substantial effects on the success of salmon and other fishery resources. Climate change is expected to affect such coastal currents, and possibly the larger scale natural oscillations as well, although these effects are not yet well understood (Thomas *et al*. 2009).

In addition to carbon dioxide's heat-trapping effect, the increase in its concentration in the atmosphere is gradually acidifying the ocean (Thomas *et al*. 2009). About one-third of the carbon dioxide emitted by human activities has been absorbed by the ocean, resulting in a decrease in the ocean's pH. Since the beginning of the industrial era, ocean pH has declined demonstrably and is projected to decline much more by 2100 if current emissions trends continue (Thomas *et al*. 2009). Because less dissolved carbon is available as carbonate ions at a lower pH (Feely *et al*. 2008; Janetos *et al*. 2008), further declines in pH are very likely to continue to affect the ability of living organisms to create and maintain shells or skeletons of calcium carbonate. Ocean acidification also is anticipated to affect important plankton species in the open ocean, mollusks and other shellfish, and corals (Feely *et al*. 2008; Janetos *et al*. 2008; Royal Society 2005; Orr *et al*. 2005). Reductions in pH also affect photosynthesis, growth, and reproduction. The upwelling of deeper ocean water, deficient in carbonate and thus potentially detrimental to the food chains supporting juvenile salmon, has recently been observed along the West Coast (Feely *et al*. 2008).

It is unclear how coastal ocean conditions will respond to long-term climate change and, in turn, affect Chinook salmon and steelhead populations during their marine life stages. Results of studies by Pearcy (1992),Francis and Hare (1994), and Francis and Mantua (2003) indicate that many climate-related biophysical linkages to salmonid populations occur very early in the salmon's marine life history - likely just months after juvenile fish enter the ocean. This hypothesis that cohort survival can be greatly impacted by climate driven conditions (e.g. upwelling and resultant prey availability) when juvenile salmon enter the ocean was also found to apply to Central Valley Chinook salmon (Lindley *et al*. 2009), further indicating that coastal and estuarine environments are key areas of biophysical interaction. While there is uncertainty regarding how coastal ocean conditions will respond to long-term climate change, it is likely that near-shore marine areas will remain important for salmon survival.

6.3 Climate Change Effects on Ocean Conditions

Most climate factors affect the entire West Coast complex of salmonids. This is particularly true in their marine phase, because the California populations are believed to range fairly broadly along the coast and intermingle, and climate impacts in the ocean occur over large spatial scales (Schwing 2009). Because ocean warming will be widespread, populations at the southern extreme of their ranges will be most susceptible to future warming. Salmon and steelhead residing in coastal areas where upwelling is the dominant process are more sensitive to climate-driven changes in the strength and timing of upwelling. Coastal sea level is generally not a major issue along the West Coast, but future sea level rise will be important to juvenile fish in the San Francisco Bay and Delta, as well as in lagoons and estuaries where the annual cycle of bar development and breaching are important to salmonid life history strategies. Perhaps the greatest uncertainty is how ocean acidification will affect salmonids and their marine ecosystem (Schwing 2009). The following is a general discussion of anticipated future changes in ocean conditions, as they may affect off-shore areas used by winter- and spring-run Chinook salmon, and steelhead during their marine life stages.

6.3.1 California Current Ecosystem

The California Current Ecosystem (CCE) is designated by NMFS as one of eight large marine ecosystems within the United States Exclusive Economic Zone. 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 (NMFS 2009). 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 (**Figure 6-3**). 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. 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 before such shifts are noticed in the physical oceanographic records (Osgood 2008). 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 (Osgood 2008). The following provides a summary of these issues, based upon the analysis developed as part of NMFS' framework for a long-term plan to address climate impacts on living marine resources (Osgood 2008).

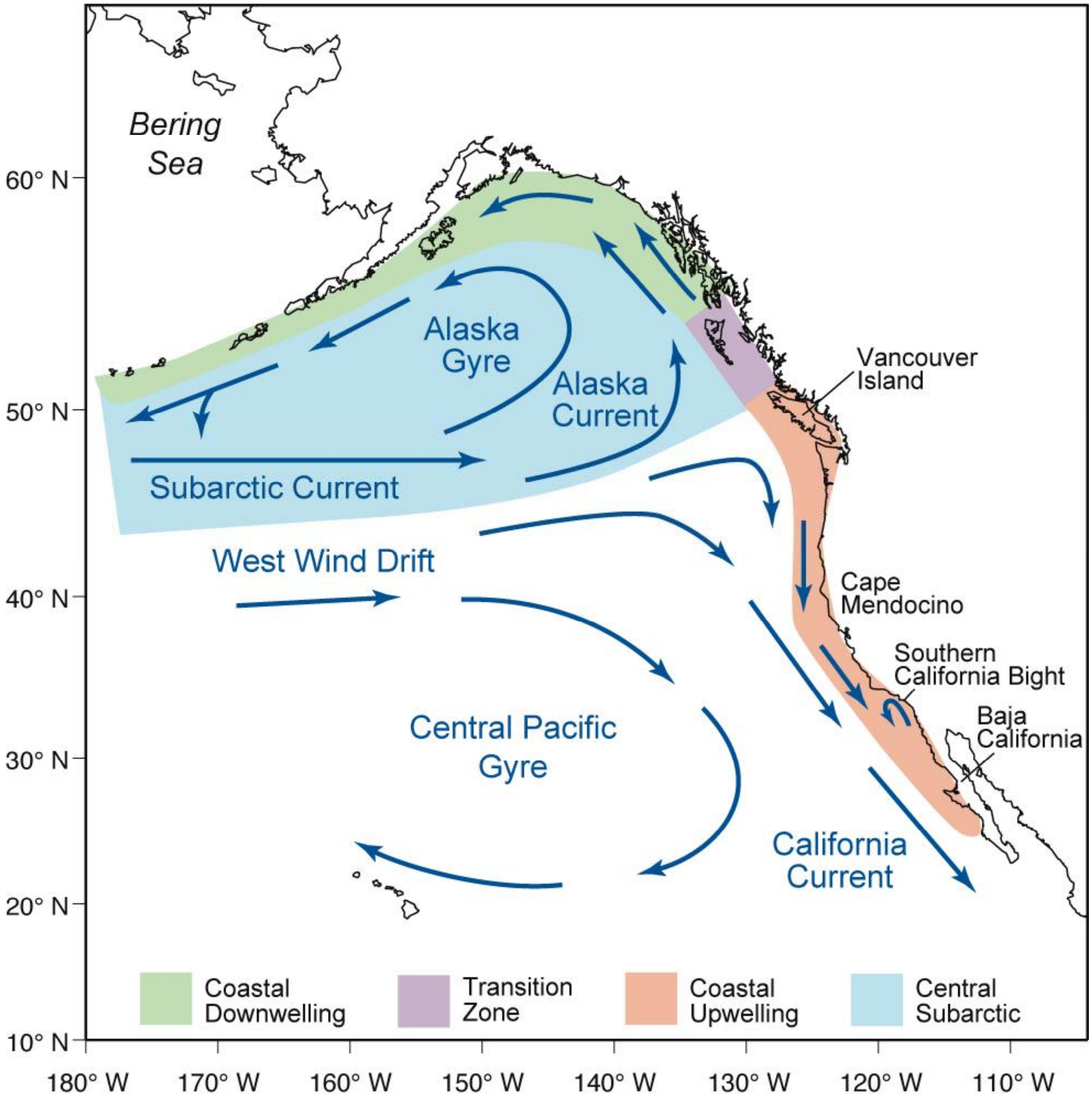

Figure 6- 3. The Principal Ocean Currents Affecting the Coastal Waters off of California. Eastward flow (West Wind Drift) bifurcates as it nears the west coast. The southward arm (the California Current) transports, cool, low salinity, nutrient-rich water along the U.S. west coast. (Source: Image from J.A. Barth, Oregon State University)

INCREASED FUTURE CLIMATE VARIABILITY

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, more frequent and severe winter storms are expected to occur, 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 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; 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 expected to experience a greater frequency of years consistent with historical periods of lower productivity (e.g., positive Pacific Decadal Oscillation values). Based on ongoing observations, a positive Pacific Decadal Oscillation and a 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).

THE EXTENT AND TIMING OF FRESHWATER INPUT

While variability in ocean conditions has substantial impacts on salmon survival and growth, future changes in freshwater and river conditions also will have a great effect on production of anadromous fish. Warmer air temperatures will result in more precipitation earlier in the year, and less snowpack. Changes in the seasonal and inter-annual timing and intensity of rainfall and snowpack, for example, are expected to increase winter and spring runoff and decrease summer runoff. These hydrologic changes may alter the way that water supplies from the Sacramento River are managed for hydropower generation and water storage, which may affect the manner in which Chinook salmon, steelhead and other estuarine-dependent species are managed.

Climate models project the 21st Century will feature greater annual precipitation in the Pacific Northwest, extreme winter precipitation events in California, and a more rapid spring snowmelt leading to a shorter, more intense spring period of river flow and freshwater discharge (Thomas *et al*. 2009). These changes are projected to considerably alter coastal stratification and mixing, riverine plume formation and evolution, and the timing of transport of anadromous fish populations to and from the ocean. A warmer and drier future also means that extra care will be needed in planning the allocation of water for the coming decades (Thomas *et al*. 2009). The current allocation of water resources between salmon and human requirements in the western United States has been a critical factor in the success of many salmon populations, and will be more so if future water availability is altered (Osgood 2008).

CHANGES IN THE TIMING AND STRENGTH OF THE SPRING TRANSITION, AND THEIR RESULTANT EFFECTS ON MARINE POPULATIONS

The primary 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 along-shore 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 southward winds that cause coastal upwelling are likely to increase in magnitude, these winds may be less effective in driving vertical transport of nutrient-rich water because it is not known if these winds will be able to over-ride increased water column stratification (Osgood 2008; NMFS 2009). 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 ocean 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 (Osgood 2008). This will make it more difficult for winds and 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 throughout the salmon marine habitat (with the possible exception of the nearshore coastal upwelling zones) (Osgood 2008).

Should global warming result in shorter winters in the Pacific Northwest, areas where production is light limited (e.g., the northern California Current) may see higher productivity (Osgood 2008). During most years since 2002, phytoplankton blooms are initiated as early as February off northern California in years when storm intensity is low. These early blooms result in bursts in egg production by both copepods and euphausiids, initiating a cohort of animals that reach adulthood one to two months earlier than a cohort that is initiated with the onset of upwelling during 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 (Osgood 2008).

OCEAN WARMING AND INCREASED STRATIFICATION, AND THEIR RESULTANT EFFECTS 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 (Osgood 2008). Warmer water temperatures also will affect freshwater salmon and steelhead habitats by reducing habitat opportunity on both spatial and seasonal time scales. In coastal and oceanic regions, the southern boundaries of pelagic habitats used by many populations are expected to 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 (Osgood 2008). The vertical gradient in ocean water temperature off of the California coast 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. Because 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 (Osgood 2008).

CHANGES TO OCEAN CIRCULATION AND THEIR RESULTANT EFFECTS ON SPECIES DISTRIBUTION AND COMMUNITY STRUCTURE

NMFS (2008) states that this is a climate-induced ecosystem concern primarily for the northern California Current, although changes in transport are known to have subtle effects on the entire Current. A particular biological concern is related to the variability in the transport of organisms, which impacts zooplankton species composition and regional recruitment patterns for demersal fish stocks.

As previously discussed, the California Current extends from the northern tip of Vancouver Island, Canada to southern Baja California, Mexico. 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 (Osgood 2008). 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 observed during summer (Osgood 2008).

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 Pacific Decadal Oscillation. During a cool phase, all of the northern CCE becomes more sub-Arctic in character (both shelf-slope-oceanic regions); during a warm phase of the Pacific Decadal Oscillation, the water masses and associated copepod community become 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 Pacific Decadal Oscillation is in a 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 over the phytoplankton and zooplankton species that dominate the current (**Figure 6-4**).

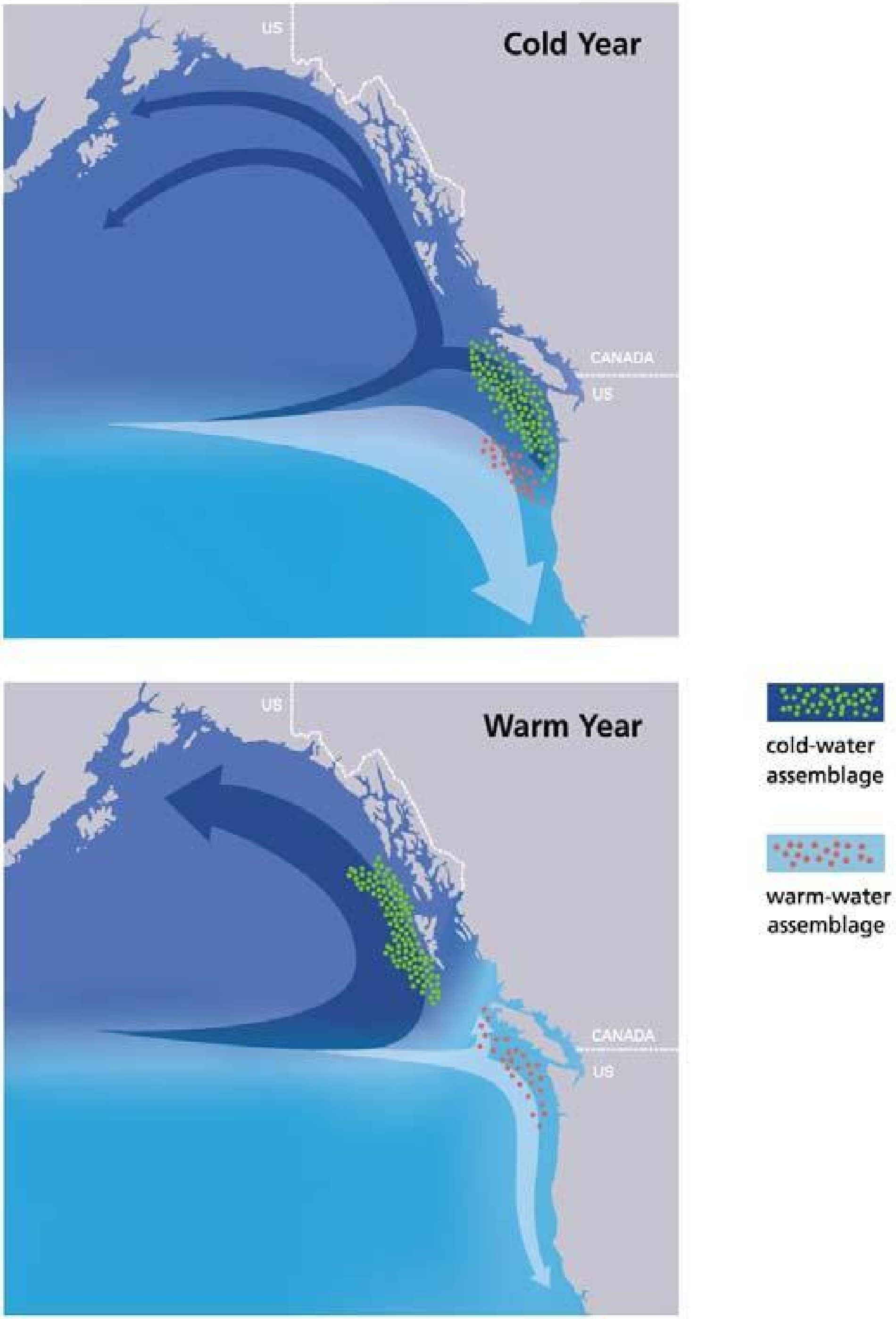

Figure 6-4. Schematic of the Flow of the North Pacific Current South into the California Current and North into the Gulf of Alaska. Cool years (such as La Niña and negative PDO years) are associated with greater flow into the California Current, which favors a southward displacement of coldwater and warmwater species. ***(Source: Osgood 2008)***

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, changes reflected by Pacific Decadal Oscillation shifts may result in local food chains that have considerably different bioenergetic content. Given, for example, that: (a) salmon returns are low when the Pacific Decadal Oscillation is in a positive, warm water phase, but high when the Pacific Decadal Oscillation is in a negative, cold-water phase; and (b) salmon returns to Pacific Northwest rivers are highly correlated with copepod community structure (Peterson and Schwing 2003), variations in the bioenergetic content of the food web may represent a mechanistic link between Pacific Decadal Oscillation sign change and salmon survival (Osgood 2008). This mechanistic link may also apply to Chinook salmon originating from the Central Valley because some of the source waters that supply the Gulf of the Farallones, where Central Valley salmon first enter the ocean, originate in the Gulf of Alaska and Central Valley Chinook salmon abundance was found to be correlated with prey availability in the Gulf of the Farallones (Wells *et al*. 2012).

Northward shifts in distribution also are 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. Alternatively, if upwelling strengthens due to global climate change, regardless of the sign of the Pacific Decadal Oscillation, cold-water species should still be favored in the coastal upwelling zones (Osgood 2008). 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 (Osgood 2008).

6.4 Climate Change Effects on Salmon and Steelhead in the Central Valley

In California, there have been observed changes in air temperatures, annual precipitation, runoff, and sea levels over the past century (Anderson *et al*. 2008). Regional-scale climate models for California are in broad agreement that temperatures in the future will warm significantly, total precipitation may decline, and snowfall will decline significantly (Lindley *et al*. 2007). Literature suggests that by 2100, mean summer temperatures in the Central Valley may increase by 2 to 8°C, precipitation will likely shift to more rain and less snow, with significant declines in total precipitation possible, and hydrographs will likely change, especially in the southern Sierra Nevada mountains. Thus, climate change poses an additional risk to the survival of salmonids in the Central Valley. As with their ocean phase, Chinook salmon and steelhead will be more thermally stressed by stream warming at the southern ends of their ranges (e.g., Central Valley Domain). For example, warming at the lower end of the predicted range (about 2°C) may allow spring-run Chinook salmon to persist in some streams, while making some currently utilized habitat inhospitable (Lindley *et al*. 2007). At the upper end of the range of predicted warming, very little spring-run Chinook salmon habitat is expected to remain suitable (Lindley *et al*. 2007).

The complex life history of salmonids as well as the complexity of their multiple aquatic habitats makes it difficult to isolate what environmental factors, or drivers, are responsible for variability in these populations

(Schwing 2009). Overall, the climate-species linkages for salmon are extremely complex. In a recent report to the Pacific Fishery Management Council, CDFW identified 46 possible reasons for the collapse of the 2004 and 2005 broods of Central Valley fall-run Chinook salmon. It is difficult to isolate the immediate effect of an individual stressor on a species, and most stressors impact many species at multiple trophic levels. Further, it is not likely that there is one single stressor, but a combination of several factors that drive ecosystem variability and change (Schwing 2009). Nevertheless, it is possible to focus on a relatively small number of factors that are sufficiently sensitive to climate change and impact the populations and freshwater and marine ecosystems of California anadromous salmonids.

This Recovery Plan addresses the California Central Valley steelhead DPS, and two Chinook salmon ESUs - Sacramento River winter-run Chinook salmon, and Central Valley spring-run Chinook salmon. Because of their extended use of the Sacramento and San Joaquin River systems, they are very dependent on runoff from the Sierra snowpack and the variability of precipitation affecting it (Osgood 2008), as previously discussed. The future climate of the freshwater habitats of the Central Valley Domain is expected to include:

- ☐ More frequent intense winter storms, high stream flow events, and floods
- ☐ Earlier snowmelt, with higher peak flows in winter, less spring runoff, and much lower summer flows
- ☐ Considerably warmer stream, river and ocean water temperatures during the summer
- ☐ Greater inter-annual precipitation variability, more frequent wet and drought years, and extended droughts
- ☐ Years with weaker fall storms, and delays in the onset of high stream flows
- ☐ More frequent wildfires and infestations, and increased erosion and sedimentation

The impacts of climate change on winter-run and spring-run Chinook salmon will differ due to differences in their life history. Winter-run Chinook salmon adults return and migrate upstream in winter through early spring, where they hold for several months before spawning in late spring and summer (Williams 2006). This spawning timing and subsequent fry emergence allows winter-run Chinook salmon juveniles to rear and move downstream during the cooler fall, winter, and spring months (Yoshiyama *et al*. 1998). That is, the juveniles can rear in freshwater for several months, without being exposed to stressful summer water temperatures. However, incubation, the most temperature-sensitive life stage, coincides with the time when river temperatures can exceed the lethal range for embryo incubation. Thus, winter-run Chinook salmon occur currently only in the Sacramento River, where summer water temperatures are cool enough to enable successful embryo incubation, but warm enough in winter to support juvenile rearing (Stillwater 2006 in Schwing 2009). They also spawn in deeper water than other populations (Moyle 2002). Juvenile winter-run Chinook salmon have historically exploited the floodplain habitat created by winter flooding in the Sacramento River Basin, which results in higher juvenile growth rates and presumably higher ocean survival (Sommer *et al*. 2001 in Schwing 2009).

The life history of spring-run Chinook salmon is to migrate upstream in spring, hold through the summer in deep pools, and then spawn in early fall, with juveniles emigrating after either a few months or a year in freshwater. However, they have considerable flexibility in their life history strategies. Age at spawning for spring-run Chinook salmon varies from two to four years.

Central Valley watersheds are fed predominantly by runoff from Sierra snowmelt, which has been historically highest during the late spring and early summer. The resulting high flow allows Chinook salmon to reach their summer holding areas, while the lower flow extending from the summer into early fall is cool enough for spawning. In the San Joaquin River drainage, snowmelt at high elevations produced a long runoff period that benefited spring-run Chinook salmon, making them the dominant run in the region. However, the recent trend toward an earlier seasonal runoff and lower flow in spring and summer has reduced the potential for survival in these watersheds, and will make the transit of adults returning to their spawning streams more difficult (see watershed profile information for individual rivers located in the Southern Sierra Nevada Diversity Group).

Because eggs and juveniles are less tolerant of warm water temperatures, spawning occurs during the fall, after streams cool. On their migration to the ocean, juvenile fish access temporary habitats with warmer water temperatures and abundant food in floodplain, tidal marsh, and estuarine habitats. These habitats are very important in smolt growth and survival - smolt size at ocean entry strongly affects survival during the first year at sea (Williams 2006). After reaching the ocean in the late spring and summer, smolts forage near the coast on crustaceans, euphausids, and prey fishes (MacFarlane and Norton 2002) that are associated with upwelling. Smolt survival over their first winter is dependent on a threshold of prey and the resultant smolt condition after the first summer at sea (Williams 2006).

Because of their close proximity, a relatively small wildfire could simultaneously burn the headwaters of all three remaining spring-run Chinook populations. Such a fire has a 10 percent chance of occurring in any given year in California (Lindley *et al*. 2007), but this probability will increase due to climate change. Prolonged drought due to lower precipitation shifts in snowmelt runoff, and greater climate extremes could also easily render most existing spring-run Chinook salmon habitat unusable, either through temperature increases or lack of adequate flows.

Increased water temperature, low flow, drought and other climate-related events will compound the threats to Chinook salmon due to human manipulation of their freshwater habitats. Because of these watersheds' great dependence on Sierra snowpack melt, the projected shift toward earlier runoff (Dettinger and Cayan 1995; Cayan *et al*. 2001) will exacerbate sensitivity to low flow and warm stream conditions at critical life stages. Winter-run Chinook salmon are especially vulnerable to climate warming, prolonged drought, and other catastrophic climate events, because they have only one remaining population that spawns in the hottest time of the year (also see the conceptual recovery scenario for winter-run Chinook salmon). Additionally, future ocean productivity will decline due to altered upwelling cycles, thus reducing prey availability and salmon ocean survival (NMFS 1997 in Schwing 2009).

Central Valley steelhead also exhibit a flexible life history, allowing them to compensate for the variable conditions and extremes of their habitat (McEwan 2001). Most juveniles remain in streams for one or two years before becoming smolts and emigrating out to the Delta and ocean (Hallock 1961 in Schwing 2009). Others may remain in the rivers their entire lives. Temperature and water quality are critical factors for fry and juvenile survival (Moyle 2002). Fry move into cooler, deeper, faster-flowing channels in the late summer and fall (Hartman 1965, Everest and Chapman 1972, and Fontaine 1988 in Schwing 2009). Juvenile steelhead prefer deep pools with heavy cover, as well as higher-velocity rapids (Bisson *et al*. 1982, 1988 and Dambacher 1991 in Schwing 2009).

The distribution of steelhead today is greatly reduced from the historical distribution. Dams and water diversions limit steelhead access to less than 20 percent of their historical spawning and rearing areas in the Central Valley (Yoshiyama *et al*. 2001; Lindley *et al*. 2006). Climate warming will further restrict access to cool water streams. Most of the same climate factors that affect other California steelhead populations are critical to Chinook salmon. The diversity and variability of their life history complicates their management. Yet this same attribute reduces their vulnerability to climate change.

Additionally, low flows during juvenile rearing and outmigration are associated with poor survival through the Delta (Kjelson and Brandes 1989; Baker and Morhardt 2001; and Newman and Rice 2002) and poor returns in subsequent years (Speed 1993). Climate change also may impact Central Valley salmonids through community effects. For example, warming may increase the activity and metabolic demand of predators, reducing the survival of juvenile salmonids (Vigg and Burley 1991).

6.5 Concepts for Buffering Climate Change Effects and Application in this Recovery Plan

The general concepts of resiliency and refugia discussed below have been used in the strategy (Chapter 3) of this recovery plan to identify a distribution of habitat in the Central Valley and habitat types that are most likely to allow winter-run Chinook salmon, spring-run Chinook salmon, and steelhead to withstand the effects of climate change. This distribution of habitat is reflected in the ESU/DPS level recovery criteria relating to population spatial structure. The types of habitats that these species will need in the face of climate change have been factored into the watershed prioritizations identified in the recovery strategy.

6.5.1 Resiliency

In ecology, resiliency carries the additional meaning of how much disturbance a system can "absorb" without crossing a threshold and entering an entirely different state of equilibrium (e.g., distinctly different physical habitat structure or conditions) (Bakke 2009**.** In regard to recovery, habitat restoration, and conservation of at-risk aquatic species, resiliency also requires that certain key habitat characteristics or processes will change little, or not at all, in response to climate change. When it comes to stream aquatic habitat, the most important elements to remain steady are temperature and disturbance regime (Bakke 2009). Resiliency is temporally dependent and given enough time, large disturbances are virtually certain to occur on the landscape and to the climate. Resiliency can only function on a landscape scale; there must be enough individual rivers available with the appropriate habitat and connectivity so that a disturbance to one portion of the system has a minimal impact on at-risk aquatic species because other parts of the system are able to support sensitive populations through the recovery and recolonization period (Bakke 2009).

In the long-term, there is no substitute for a landscape that offers redundancy of habitat opportunities. This recovery plan incorporates the resiliency concept by using the Central Valley diversity groups as recovery units (see Section 3.2.1) and generally calling for multiple viable populations within each of the units. Having an ESU or DPS spatial structure with each diversity group represented and population redundancy within each diversity group follows the historic population structure, which allowed the species to withstand extreme climactic events and persist for thousands of years. Because the biological recovery criteria for each of the three species covered in this plan (Section 4.3.4) are based on the species' historic spatial structure, it is assumed that an ESU/DPS that meets those criteria should be resilient to disturbances caused by climate change.

6.5.2 Refugia

Refugia are places in the landscape where organisms can go to escape extreme conditions (Bakke 2009). Typically, this refers to short-term conditions such as floods or high water temperatures. But in the context of climate change, refugia can also be places where a population may persist through decades and centuries of unfavorable climate conditions and instability. For coldwater obligate fish species, refugia will continue to be areas where groundwater emergence influences water temperature and volume. These refugia will exist on multiple scales: (1) local areas of cold water emergence within a reach otherwise insufficiently cold; (2) lower sections of rivers downstream of reservoirs with large amounts of coldwater storage; and (3) entire stream systems where groundwater hydrology is dominant or snowmelt hydrology is preserved due to high elevations. Thus, the same set of circumstances producing cold water conditions in the current landscape may, to varying degrees, produce thermal refugia against global warming.

The coldwater refugia concept has been applied in this recovery plan as a factor in the prioritization of watersheds. For example, Battle Creek, Mill Creek, and Deer Creek each were identified as core 1 watersheds for spring-run Chinook salmon, in part, because fish in those watersheds should be able to withstand warming air temperatures either by coldwater spring inputs (Battle Creek) or having access to holding and spawning habitat at relatively high elevation (Mill Creek and Deer Creek). As another example of how the refugia concept was applied in this recovery plan, the Sacramento River downstream of Shasta Dam was identified as a core 1 area for winter-run Chinook salmon, in part, because, in wetter year types, suitable water temperatures for spawning and incubation are provided during the summer via coldwater releases from the dam. Even with the projected effects of climate change, it is likely that suitable temperatures for winter-run Chinook salmon will be available downstream of Shasta Dam during wetter years. However, considering the expected increase in the frequency of dry years, which often result in mortality during egg incubation, it will be increasingly difficult to maintain the species without access to coldwater in the summer on a more consistent annual basis. As such, the McCloud River watershed, which receives coldwater from high elevation snowmelt and from springs, has been identified as a primary area for reintroduction. Reintroducing salmon and steelhead to historic high elevation habitats is a key part of the recovery strategy (see Section 3.3.2) because coldwater refugia will be needed to allow the species to withstand climate change.

7.0 Implementation

> *"Although recovery actions can, and should, start immediately upon listing a species as endangered or threatened under the ESA, prompt development and implementation of a recovery plan will ensure that recovery efforts target limited resources effectively and efficiently into the future."*
>
> NMFS 2010b. Interim Endangered and Threatened Species Guidance

7.1 Costs and Benefits of Salmon and Steelhead Recovery

Implementing the recovery actions in this recovery plan will be expensive, with a rough estimate ranging from $17 to $37 billion[29]. This investment in recovery of salmon and steelhead will result in economic, societal and ecosystem benefits. Monetary investments in watershed restoration projects can promote the economy in a myriad of ways. These include stimulating the economy directly through the employment of workers, contractors and consultants, and the expenditure of wages and restoration dollars for the purchase of goods and services. Habitat restoration projects have been found to stimulate job creation at a level comparable to traditional infrastructure investments such as mass transit, roads, or water projects (Oregon Watershed Enhancement Board 2010). In addition, viable salmonid populations provide ongoing direct and indirect economic benefits as a resource for fish, recreation, and tourist related activities. Dollars spent on salmon and steelhead recovery will promote local, State, Federal and tribal economies, and should be viewed as an investment with both societal (clean rivers, healthy ecosystems) and economic returns.

The largest direct economic returns resulting from recovered salmon and steelhead are associated with sport and commercial fishing. On average 1.6 million anglers fish the Pacific region annually (Oregon, Washington and California) and 6 million fishing trips were taken annually between 2004 and 2006 (NMFS 2010a). Most of these trips were taken in California and most of the anglers lived in California. The California salmon fishery is estimated to generate $118 to $279 million in income annually, and provide roughly two to three thousand jobs (Michael 2010). With a revived sport and commercial fishery, an increase in economic gains and the creation of jobs would be realized across California, but most notably for river communities and rural coastal counties.

Many of the actions identified in this Recovery Plan are designed to improve watershed-wide processes which will benefit many native species of plants and animals (including other state and federally listed species) by restoring natural ecosystem functions. In addition, restoration of habitat in watersheds will provide substantial benefits for human communities. Some of these benefits are: improving and protecting the quality of important surface and ground water supplies; reducing damage from flooding resulting from floodplain development; and controlling invasive exotic animal and plant species which can threaten water supplies and

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[29] Estimate derived by summing the costs of all recovery actions presented in Chapter 5.

increase flooding risk. Restoring and maintaining healthy watersheds also enhances important human uses of aquatic habitats, including outdoor recreation, ecological education, field based research, aesthetic benefits, and the preservation of tribal and cultural heritage.

The final category of benefits accruing to recovered salmon and steelhead populations are even more difficult to quantify and are related to the ongoing costs associated with maintaining populations that are at risk of extinction. Significant funding is spent annually by entities (Federal, State, local, private) in order to comply with the regulatory obligations that accompany populations that are listed under the ESA.

Important activities, such as water management for agriculture and urban use, are now constrained to protect ESA listed populations of salmon and steelhead. Recovering the salmonid populations so the protections of the ESA are no longer necessary will also result in elimination of the regulatory requirements imposed by the ESA, and allow greater flexibility for land and water managers to optimize their activities and reduce costs related to ESA protections. Salmon recovery is best viewed as an opportunity to diversify and strengthen the economy while enhancing the quality of life for present and future generations.

7.2 Integrating Recovery Implementation into NMFS Actions

It is a challenging undertaking to facilitate a change in practice and policy that reverses the path towards extinction of a species to one of recovery. This change can only be accomplished with effective outreach and education, strong partnerships, focused recovery strategies and solution-oriented thinking that can shift agency and societal attitudes, practices and understanding.

Implementation of the recovery plan by NMFS will take many forms and is generally and specifically described in the NMFS Protected Resources Division Strategic Plan 2006 (NMFS 2006). The Recovery Planning Guidance (NMFS 2010b) also outlines how NMFS will cooperate with other agencies regarding plan implementation. These documents, in addition to the ESA, will 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).

NMFS actions to promote and implement recovery planning include:

- ☐ 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).
- ☐ Conducting outreach and education.
- ☐ Facilitating a consistent framework for research, monitoring, and adaptive management that can directly inform recovery objectives and goals.
- ☐ Establishing an implementation tracking system that is adaptive and pertinent to support the annual reporting for the Government Performance and Results Act, Bi-Annual Recovery Reports to

Congress and the 5-Year Status Reviews.

To achieve recovery, NMFS will need to promote the recovery plan and provide needed technical information and assistance to other entities that implement actions that may impact the species' recovery. For example, NMFS intends to work with key partners on high priorities such as facilitating fish passage assessments and ensuring protective measures consistent with recovery objectives are included in County General Plans.

While recovery plans are guidance documents not regulatory documents, the intent is that they are used to prioritize and target necessary actions for the survival and recovery of the species. The Recovery Planning Guidance (NMFS 2010b) specifically outlines NMFS' obligations:

> "...the ESA clearly envisions recovery plans as the central organizing tool for guiding each species' recovery process. They should also guide Federal agencies in fulfilling their obligations under section 7(a)(1) of the ESA… and provide context and a framework for implementing other provisions of the ESA with respect to a particular species, such as section 7(a)(2) consultations on Federal agency activities, development of Habitat Conservation Plans or Safe Harbor agreements under section 10, special rules for threatened species under section 4(d), or the creation of experimental populations in accordance with section 10(j)."

As further discussed below, this recovery plan is intended to inform decisions made pursuant to or concerning critical habitat designation under section 4, land acquisition under section 5, take prohibitions through sections 4(d) and 9, cooperation with state(s) under section 6, needed research under section 10, and fishery management actions taken and Essential Fish Habitat (EFH) consultations conducted under the provisions of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

The approaches NMFS intends to use when implementing various sections of the ESA are discussed in detail and are summarized in **Table 7-1**. These approaches are intended to formalize 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.

7.2.1 Working with Constituents and Stakeholders

NMFS commits to using recovery plans as a guiding mechanism for its daily endeavors. Successful implementation of this recovery plan will require the support, efforts and resources of many entities, from Federal and State agencies to individual members of the public. NMFS commits to working cooperatively with other individuals and agencies to implement recovery actions and to encourage other Federal agencies to implement actions where they have responsibility or authority.

7.2.2 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 develop recovery plans. Critical habitat designations may be revised as needed to reflect recovery strategies.

Sacramento River winter-run Chinook salmon critical habitat was designated on June 16, 1993, and includes the Sacramento River from Keswick Dam (RM 302) to Chipps Island (RM 0) at the westward margin of the Delta;

all waters from Chipps Island westward to Carquinez Bridge, including Honker Bay, Grizzly Bay, Suisun Bay, and Carquinez Strait; all waters of San Pablo Bay westward of the Carquinez Bridge; and all waters of San Francisco Estuary to the Golden Gate Bridge north of the San Francisco/Oakland Bay Bridge (58 FR 33212). CV spring-run Chinook salmon and CV steelhead critical habitat was designated on September 2, 2005, and includes stream reaches such as those of the Feather and Yuba rivers, Big Chico, Butte, Deer, Mill, Battle, Antelope, and Clear creeks, the Sacramento River, as well as portions of the northern Delta (70 FR 52488).

NMFS will reevaluate the designations in light of the data and criteria developed for this plan, and may propose the designation of additional habitat. The key recovery areas, special management considerations and recovery priorities identified in this recovery plan will inform future critical habitat designations. Certain unoccupied historic habitats that may be essential for recovery, and that are recommended for future critical habitat consideration include:

Sacramento River winter-run Chinook salmon

- ☐ Little Sacramento River
- ☐ McCloud River
- ☐ Battle Creek
- ☐ Non-natal rearing tributaries to the Sacramento River

Although these areas may provide sites and habitat components that are consistent with the physical and biological features that are essential for the conservation of Sacramento River winter-run Chinook salmon described in the final rule designating critical habitat for that ESU (58 FR 332112, 33216-17; June 16, 1993), a more detailed evaluation of habitat conditions will need to be undertaken when re-considering whether a system should be proposed for critical habitat. In the Little Sacramento and McCloud rivers and Battle Creek, these sites and habitat components include freshwater rearing, migration and spawning habitats. Although these habitats are currently blocked by dams, the many miles of relatively unimpaired cold water habitats and the fact that they historically supported winter-run Chinook salmon may make these areas highly valuable to the recovery of the species. Non-natal rearing tributaries to the Sacramento River include freshwater rearing habitat. Some non-natal rearing areas potentially have a high value because they provide critical and improved growing conditions, particularly during high winter flow events on the Sacramento River.

CV spring-run Chinook salmon and CV steelhead

- ☐ Little Sacramento River
- ☐ McCloud River
- ☐ North Fork Feather River
- ☐ North, Middle and South Yuba River
- ☐ Upper American River
- ☐ Mokelumne River
- ☐ North Fork Stanislaus River
- ☐ Tuolumne River
- ☐ Merced River
- ☐ San Joaquin River (CV spring-run Chinook salmon only)

This list represents the unoccupied historic habitat identified in the Conceptual Recovery Footprint maps presented in Chapter 3 (Figures 3-5 and 3-6). Although these areas may provide sites and habitat components consistent with the primary constituent elements (PCEs) essential for the conservation of CV spring-run Chinook salmon and CV steelhead that are included in the critical habitat designated for this ESU and DPS (50 C.F.R. § 226.211(c)), a more detailed evaluation of habitat conditions will need to be undertaken when re-considering whether a system should be proposed for critical habitat.[30]

Section 4(d) of the ESA directs the Secretary of Commerce (who has delegated such authority to NMFS) to issue regulations as deemed necessary and advisable to conserve species listed as threatened. ESA section 9 prohibits any take of species listed as endangered. Pursuant to regulations issued under section 4(d) of the ESA (commonly referred to as 4(d) rules), NMFS may also prohibit the take of threatened species. Section 4(d) of the ESA gives NMFS the discretion to customize prohibitions and regulate activities to provide for the conservation of threatened species when applying the take prohibitions that apply to endangered species under ESA section 9. A 4(d) rule is currently in place for Central Valley spring-run Chinook salmon and CV steelhead at 50 C.F.R. § 223.203. That 4(d) rule applies the endangered species prohibitions of section 9(a)(1) to threatened Central Valley spring-run Chinook salmon and CV steelhead, subject to certain limitations. Those limitations include limits on take prohibitions found in 50 C.F.R. § 223.203 (b).

Based on our review of the special management considerations necessary to implement recovery actions for spring-run Chinook salmon and steelhead, development of additional 4(d) limits on the take prohibitions for the following activities are recommended for consideration:

- ☐ Fish passage facilities that are consistent with NMFS fish passage criteria
- ☐ Levee construction or maintenance activities that meet the following requirements, provided they are applicable to the levee activity being considered:
  - Part of a comprehensive flood management program that has been approved by NMFS and includes a detailed conservation strategy for implementing recovery actions for floodplain and riparian habitat restoration
  - Levee relocations that create frequently activated floodplain areas (Williams *et al.* 2009), and minimize the potential for the stranding of juvenile fish
  - Slurry wall construction within urban river corridors
  - In-river repair and maintenance actions within urban flood corridors that meet NMFS design and maintenance criteria for urban levees
- ☐ Spawning gravel augmentation projects below dams
- ☐ Adult and juvenile fish collection and relocation actions that are part of a NMFS-approved fish reintroduction program

The above recommendations are made because the activities could provide for the conservation of threatened species, potentially without involving the additional time and cost involved with methods of ESA compliance that are currently available for these activities.

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[30] As described in the Recovery Strategy (Chapter 3), it is important to note that it is not necessary to re-establish populations in all of these watersheds to meet the recovery criteria for CV spring-run Chinook salmon or CV steelhead. In fact, successful reintroductions into just a few areas will allow the recovery criteria to be met.

7.2.3 ESA Section 5

Section 5 of the ESA provides that the Secretary of the Interior and the Secretary of Agriculture, with respect to the National Forest System, shall establish and implement a program to conserve fish, wildlife, and plants, including listed endangered and threatened species. To carry out this program, the appropriate Secretary shall use certain land acquisition and other authority, and is given additional authority related to land and water acquisition. Multiple National Forests lands are present within the Central Valley domain.

7.2.4 ESA Section 6

Section 6 of the ESA describes protocols for consultation and agreements between NMFS and the states for the purpose of conserving threatened or endangered species. The current agreement under section 6 of the ESA between NMFS and California covers abalone and green sturgeon. NMFS will explore options with CDFW for including winter-run Chinook salmon, spring-run Chinook salmon, and steelhead in the existing or a new agreement under section 6 of the ESA.

Table 7-1. Summary of approaches NMFS intends to use when implementing various sections of the ESA and MSFCMA.

Authority	Description	Implementation Actions
ESA Section 7	Section 7(a)(1) Interagency Cooperation (Use of authorities)	Use threats assessments and recovery actions to guide Federal partners to further the conservation of listed Central Valley salmon and steelhead.
ESA Section 7	Section 7(a)(2) Interagency Cooperation (Consultation)	Continue to use the viable salmonid population concept described in this Recovery Plan to help determine effects of proposed actions on the likelihood of species' survival and recovery.
	Note: Permits issued section 10(a)(1) of the ESA also undergo section 7 consultation prior to issuance.	Use threats assessments and recovery strategy as a guide to prioritizing consultations when making workload decisions.
		Place high priority on consultations for actions that implement recovery strategy or specific actions.
		Streamline consultations for those actions with little or no effect on recovery areas or priorities.
ESA Section 9	Section 9 Enforcement	Prioritize those actions and areas deemed of greatest threat or importance for focused efforts to halt illegal take of listed species.
ESA Section 10	Section 10(a)(1)(B) Incidental Take Permits	Prioritize permit applications that address identified research and monitoring needs in the recovery plan.
		Prioritize cooperation and assistance to landowners proposing activities or programs designed to achieve recovery objectives.
Magnuson-Stevens Fishery Conservation and Management Act	Fishery Management	Implement fishery regulations to maintain salmon harvest levels at or below those necessary to allow for the recovery of listed salmon and steelhead.
		Implement fishery regulations to reduce bycatch of salmon in federally-managed fisheries.

7.2.5 ESA Section 7

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 and threatened species…." "Conservation" is defined in the ESA as "the use of all methods and procedures which are necessary to bring any endangered species or threatened species to the point at which the measures provided pursuant to [the ESA] are no longer necessary." 16 U.S.C. § 1532(3). . Therefore, a key theme is *recovery*. To encourage Federal agencies to fulfill their section 7(a)(1) requirement to carry out conservation programs for listed Central Valley salmon and steelhead, NMFS will:

1. Encourage development of a West Coast Region California Central Valley Area Office or Regional Memorandum of Understanding (MOU) similar to a 1994 MOU [Daily Env't Rep. (BNA) No. 188, at E-1] between Agencies (which expired in 1999), establishing a framework for cooperation and participation to further the purposes of the ESA that specifically outlines a process for coordinating and implementing appropriate recovery actions identified in recovery plans.

2. 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 salmonid conservation and recovery priorities.

3. Encourage use of conservation bank credits when appropriate to contribute toward recovery of listed anadromous salmonids in the Central Valley.

4. In addition to minimization of incidental take or effects to habitat, encourage meaningful and focused mitigation, in alignment with recovery goals for restoration and threat abatement, for actions that incidentally take listed Central Valley salmon and steelhead or affect their habitat.

5. Encourage Federal partners to include recovery actions in project proposals.

6. Conduct outreach to Federal partners, and provide an outline of 7(a)(1) obligations.

Under section 7(a)(2), Federal agencies must consult with NMFS (and/or USFWS) 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 to ensure agency actions do not jeopardize a species or destroy or degrade habitat. Consultations have helped prevent and minimize take.

To improve the section 7(a)(2) consultation process, NMFS will utilize its authorities to:

☐ Continue to use the viable salmonid population concept described in this Recovery Plan to help determine effects of proposed actions on the likelihood of species' survival and recovery.

☐ Place high priority on consultations for actions that implement recovery strategy or specific actions.

☐ Develop and maintain databases to track the amount of incidental take authorized and effectiveness of conservation and mitigation measures.

☐ Provide recommended actions in the recovery plan as section 7(a)(1) conservation recommendations as applicable.

☐ While still fulfilling all relevant statutory and regulatory requirements, focus staff priorities, to the extent possible, away from section 7 compliance in watersheds not designated as a priority for recovery and direct efforts to recovery implementation

☐ Streamline consultations for those actions with little or no effect on recovery areas or priorities.

☐ Prioritize staff efforts to carefully and consistently consider short-term and long-term impacts to watershed processes when conducting jeopardy analysis for Federal actions in key listed Central Valley salmon and steelhead watersheds.

☐ Apply the VSP framework and recovery priorities to evaluate population and area importance in jeopardy and adverse modification analysis.

☐ Encourage action agencies to purchase credits from a NMFS approved conservation bank whenever appropriate.

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.

☐ Encourage the U.S. Environmental Protection Agency (USEPA) to prioritize action 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.

☐ Encourage the Federal Highway Administration and Caltrans to develop pile driving guidelines, approved by NMFS, for all bridge construction projects in key Dependent, Independent, and other watersheds with extant listed Central Valley salmon and/or steelhead populations.

☐ Encourage the development of section 7 Conservation Recommendations to help prioritize Federal funding towards recovery actions (NMFS, USFWS, NRCS, USEPA, etc) during formal consultations.

☐ Encourage 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 such field reviews to NMFS.

☐ Encourage Federal agencies to coordinate and develop programmatic consultations for activities that contribute to the recovery of listed Central Valley salmon and steelhead, to streamline their permitting processes.

☐ Encourage all consulting agencies to provide biological assessments that comport to 50 CFR 402.14(c) for all projects in all watersheds where listed Central Valley salmon and/or steelhead are present and/or with designated critical habitat.

7.2.6 ESA Section 9

Section 9 prohibits the taking of endangered species; these prohibitions may be extended through 4(d) rules to threatened species, as discussed above. The recovery plan will assist NMFS' Enforcement personnel by targeting key watersheds essential for species recovery. Core watersheds identified in this plan should be considered the highest priority areas. NMFS biologists will work closely with NMFS Enforcement regarding the identification of threats and other activities believed to place Chinook salmon and steelhead at high risk of take and/or extirpation. Actions will include the following:

- ☐ NMFS will conduct outreach and provide enforcement with 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 to ensure activities by NMFS staff, when supporting enforcement, are focused on the highest recovery priorities.
- ☐ When a take has occurred, NMFS biologists will work with NMFS enforcement, to the extent feasible, with the development of a take case.
- ☐ NMFS enforcement will work with CDFW, in conjunction with the Joint Enforcement Agreement to increase patrols and landowner outreach in critical watersheds, particularly during droughts, when listed Central Valley salmon and steelhead are potentially at greater threat of unauthorized taking.
- ☐ Regular meetings between recovery staff and Enforcement will occur. NMFS Enforcement will place a high priority on identification and curtailment of threats in key watersheds identified for recovery.

7.2.7 ESA Section 10

Section 10(a)(1)(A) provides NMFS authority to issue permits to authorize take of listed species for scientific purposes, or to enhance the propagation or survival of listed species.

Section 10(a)(1)(B) provides NMFS authority to issue permits to authorize take of listed species that is incidental to otherwise lawful activities for non-federal entities. Requests for such a permit must be accompanied by a conservation plan that, among other things, describes the effects of the incidental taking and how the entity will minimize and mitigate those effects.

To improve the section 10 authorization process, NMFS will utilize its authorities to:

<u>Section 10(a)(1)(a) Research Permits</u>

- ☐ Prioritize permit applications that address identified research and monitoring needs in the recovery plan.
- ☐ 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.

Section 10(a)(1)(B) Habitat Conservation Plans (HCPs)

The USFWS/NMFS Habitat Conservation Planning Handbook (USFWS and NMFS 1996) stresses the need for consistency of mitigation measures for a species and for specific standards. Although, not a preferred option (according to the USFWS/NMFS HCP Handbook), if offsite mitigation is necessary this recovery plan can be used to target watersheds for recovery actions. In some circumstances off-site mitigation may provide greater opportunity for recovery than onsite mitigation (*i.e.*, if an HCP's covered activities occur in a non-focus watershed).

Within the HCP framework NMFS will utilize its authorities to cooperate and assist landowners in proposing activities or programs designed to contribute to recovery objectives.

Section 10(j) Experimental Populations

Section 10(j) of the ESA provides for the designation of specific populations of species as "experimental populations" under certain circumstances and procedures. The potential use of section 10(j) of the ESA could facilitate reintroductions by helping to minimize regulatory requirements on land and water users. This regulatory approach has been taken in order to help facilitate the reintroduction of spring-run Chinook salmon into the San Joaquin River downstream of Friant Dam. However, the regulatory context for future fish reintroductions in the Central Valley will be determined on a case by case basis.

7.2.8 Fisheries Management and EFH

Much of listed Central Valley salmon and steelhead habitat is located in areas identified as Essential Fish Habitat (EFH) for the Pacific Coast Salmon Fishery Management Plan (FMP) under the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). NMFS anticipates the objectives and recovery strategies will serve as a guide when providing conservation recommendations for actions that may adversely affect EFH. In addition, NMFS will implement fishery regulations, through coordination with PFMC, to maintain salmon harvest levels at or below those necessary to allow for the recovery of listed salmon; and NMFS will work to implement fishery regulations to reduce bycatch of listed salmon in federally-managed fisheries.

7.2.9 Coordination with other NMFS Divisions and the PFMC

Other divisions within NOAA can contribute significantly to recovery. NMFS staff will coordinate closely with the SWFSC and the NOAA Restoration Center, to assist in the development, review and funding of restoration projects.

In addition NMFS staff will need to coordinate closely with the PFMC for establishing an ecosystem-based fishery management plan to prevent overfishing of listed Chinook salmon.

7.2.10 Technical Assistance

In conjunction with NMFS' statutory authorities and obligations we are engaged in a significant amount of outreach to various constituencies where we provide technical assistance regarding listed salmon and steelhead, their habitat needs, and various life history requirements. Due to the large proportion of private lands and the limited contributions of ESA section 7, developing partnerships through providing technical assistance will be critical for recovery. Through this role NMFS will focus efforts in key areas critical for recovery through the following actions:

☐ Work with individual cities and counties throughout the Central Valley so they have sufficient information to develop city planning and land use policies protective of listed Central Valley salmon and steelhead.

☐ Continue working with the Natural Resource Conservation Service, Resource Conservation Districts, and Reclamation Districts, to encourage improved agricultural practices as well as land use practices of rural residential landowners.

☐ Prioritize cooperation and assistance to landowners proposing activities or programs designed to achieve recovery objectives.

☐ Work with the SWRCB to restore and maintain natural flow patterns of clean, cold water across the ESUs/DPS.

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