Ecosystem Restoration Program

Conservation Strategy for Restoration

of the

Sacramento-San Joaquin Delta, Sacramento Valley and San Joaquin Valley Regions



May 2014

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The Ecosystem Restoration Program (ERP) Implementing Agencies (California Department of Fish and Wildlife [CDFW], United States Fish and Wildlife Service [USFWS], and National Marine Fisheries Service [NMFS]) provide this Conservation Strategy (Strategy) to help guide future environmental restoration in the Sacramento-San Joaquin Delta and its watershed (Focus Area).

This Strategy, built on lessons learned during Stage 1 of CALFED (2000 through 2007), was developed by CDFW collaboratively with USFWS and NMFS. The Strategy identifies ERP goals and conservation priorities and processes for Stage 2 of CALFED (2008 through 2030), while providing impetus for improvement in the future. It provides flexibility so that management decisions can be made adaptively based on new scientific findings, changing circumstances, and new or modified conservation priorities. All agencies, groups, or individuals interested in resource conservation and management within the Focus Area are encouraged to use this document to help guide and coordinate their activities.

Foreword

To reduce conflicts between interest groups and move towards a restored Sacramento-San Joaquin Delta (Delta) ecosystem, the CALFED Bay-Delta Program (CALFED) was established in 1994 with the signing of the Bay-Delta Accord. The original purpose of the CALFED Program was to address four interrelated objectives: Levee System Integrity, Ecosystem Restoration, Water Supply Reliability, and Water Quality. Over the next six years specific goals and objectives of the 30-year CALFED program were elucidated in the CALFED Multi-Species Conservation Strategy (MSCS), the Programmatic Environmental Impact Statement/Environmental Impact Report (EIS/EIR), and the Record of Decision (ROD) (CALFED 2000c, 2000d, 2000e).

In 2009 the California legislature passed the Delta Reform Act, thereby authorizing new planning efforts to achieve the co-equal goals of water supply reliability and a healthy Delta ecosystem. This act created two new State agencies to help accomplish the co-equal goals, the Delta Stewardship Council (DSC) and the Sacramento-San Joaquin Delta Conservancy (Conservancy). As the State implementing agency for the CALFED Ecosystem Restoration Program (ERP), the California Department of Fish and Wildlife (CDFW) (previously known as the Department of Fish and Game) is pursuing a seamless transition from the previous structure, guided by the California Bay-Delta Authority and CALFED Science Program, to the new governance structure established by the Delta Reform Act. CDFW, the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) coordinate with the DSC and the Conservancy in the implementation of ERP activities, obtaining their guidance to assure consistency with the Delta Plan being developed by the DSC. Coordination with the DSC to promote consistency with the Delta Plan and other planning efforts will ensure that DSC actions are informed by future implementation of ERP and information gained from ERP's first seven years of restoration, research, monitoring, and assessment efforts.

The stated mission of CALFED "…is to develop a long-term comprehensive plan that would restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system." ERP is the principal CALFED program component designed to restore the ecological health of the Bay-Delta ecosystem. The approach of ERP is to restore or mimic ecological processes and to increase and improve aquatic and terrestrial habitats to support stable, self-sustaining populations of diverse and valuable species.

Implementation of the 30-Year CALFED ROD (ROD) was divided into two stages, Stage 1 (2000-2007) and Stage 2 (2008–2030). The Stage 1 Plan for Ecosystem Restoration was developed for implementation during the first seven years of the program. It was acknowledged that judging progress could not be accurately assessed during the early phases of the program. The ROD stipulated that to be successfully implemented, ERP must have a minimum of $150 million annually of dedicated funding during Stage 1 Implementation. In addition, long term implementation of ERP would include an adaptive management framework for addressing program performance.

This Conservation Strategy describes Stage 2 conservation priorities of the Sacramento-San Joaquin Delta and the Sacramento Valley and San Joaquin Valley Regions. It responds to analysis of Stage 1 research, restoration, and monitoring activities that determined the CALFED through-Delta conveyance alternative, as it had been implemented, did not achieve sufficient progress in sustaining viable populations of endangered and threatened aquatic species. Findings of Stage 1 ERP implementation are presented in this document only to the extent they inform scientific understanding of the system since the certification of the ROD in 2000.

CDFW was the lead agency in developing the Conservation Strategy, in coordination with USFWS and NMFS. This final version incorporates public and agency comments. Coordination of future updates to the Conservation Strategy will be made concurrently with updates to the Delta Plan, if and when appropriate. This Conservation Strategy will be reviewed and updated, as necessary, until implementation of the ROD is completed (2030).

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Purpose and Intended Use

The Conservation Strategy describes ERP goals and conservation priorities for Stage 2 of the CALFED Bay-Delta Program (CALFED) and was developed by the Department of Fish and Wildlife (CDFW) in coordination with the United States Fish and Wildlife Service (USFWS) and the National Oceanic and Atmospheric Administration Fisheries Service (NOAA Fisheries), collectively known as the ERP Implementing Agencies. This document serves as the conceptual framework that will guide future ERP environmental restoration, including development of conservation priorities and processes to identify and implement restoration opportunities, and monitoring to guide and improve its success in the Sacramento-San Joaquin Delta (Delta), and the Sacramento Valley and the San Joaquin Valley regions.

This Conservation Strategy builds on information presented in the Ecosystem Restoration Program Plan (ERPP) (CALFED 2000a), the Multi-species Conservation Strategy (MSCS) (CALFED 2000d), ERP Milestones Reports (CALFED 2001b) and Annual Reports (DFG 2011b), the best available science on current ecological conditions, related programs and planning efforts, and input from stakeholders and the general public. There are many different kinds of conservation planning currently underway for the Delta, Sacramento and San Joaquin Valley regions and restoration is very much a shared vision between and among the agencies, various resource users, and the public.

ERP Implementing Agencies will be using this ERP Stage 2 Conservation Strategy as a guide through the end of Stage 2 (2030). It provides a comprehensive ecosystem restoration strategy for ERP efforts in the Focus Area (Focus Area) (Figure 1), allowing flexibility in adapting responses accordingly to new scientific findings, changed circumstances and new or modified future conservation priorities. This Conservation Strategy will serve as a guide to identify programmatic-level types and locations of potential restoration actions based on conservation priorities. It is not a prescription for restoration actions at any specific site. Within this strategy is a compilation of conservation priorities, articulated from lessons learned during Stage 1, which may be used to meet ERP goals. All agencies, groups, or individuals interested in resource conservation and management within the Focus Area are encouraged to use this document as a guide to help coordinate activities to address ERP conservation priorities.

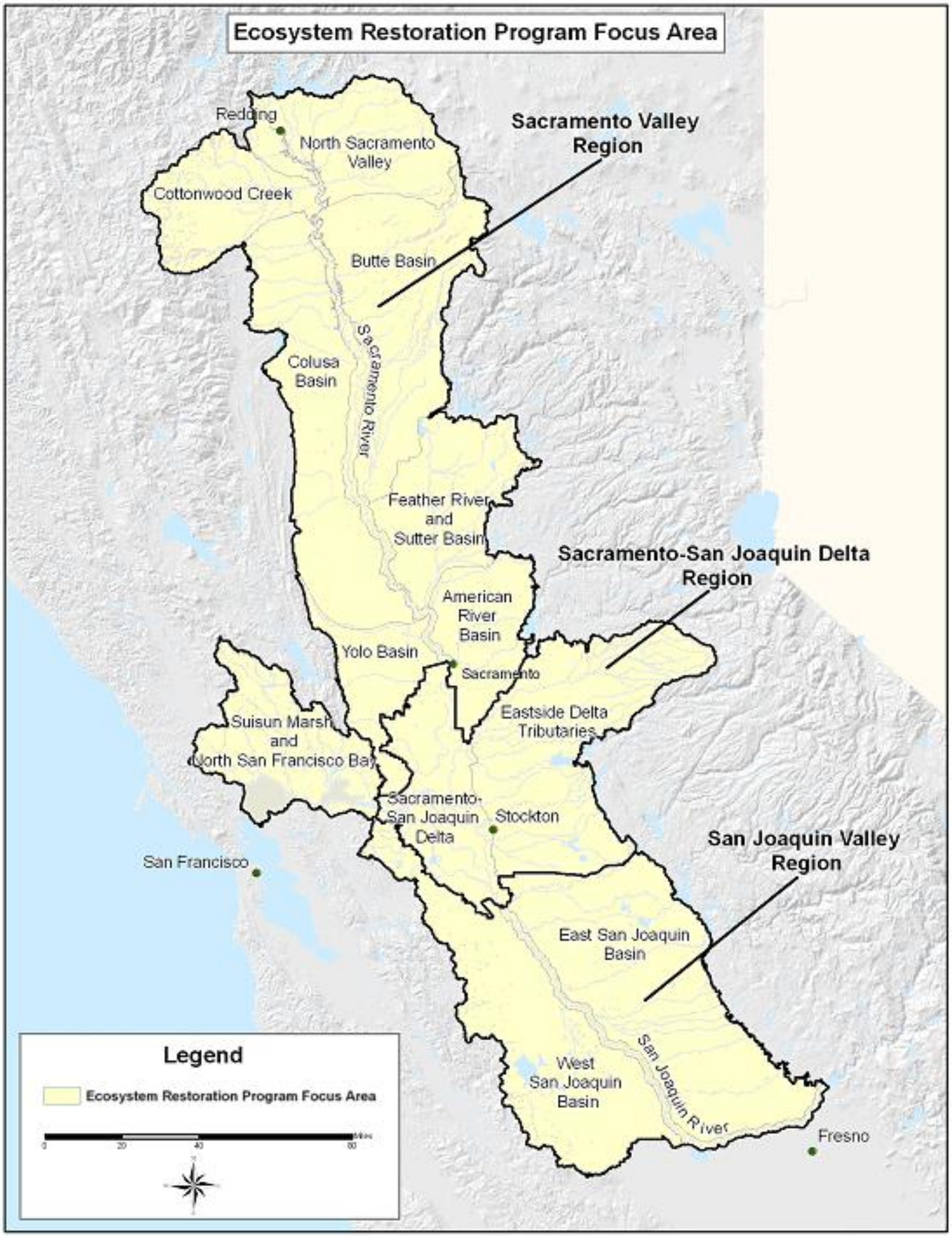

Figure 1: Map of ERP Focus Area

ERP Goals

The statements below delineate broad goals for the future condition of the Focus Area. These six goals were designed to achieve the following five functions. First, ecosystems should be resilient and able to withstand unpredictable events such as the invasion of non-native species capable of altering ecosystem processes, massive levee failures, or the collapse of some populations of native species. For this strategy, the ecosystems should be dynamic but are assumed to function in a more or less predictable fashion in response to large scale changes like global climate change. Second, ecosystems should incorporate human activity as integral parts—as managers, participants, and beneficiaries— instead of simply observers. According to this function, the ecosystems under the scope of CALFED are not completely “natural” ecosystems in which humans are primarily observers. Instead, they are systems that continue to be altered by human activities, but in a less harmful way. They include people who live and make a living in them, and produce products that benefit society. Third, in the long-term ecosystems should maintain self-sustaining populations of native species. Fourth, landscapes should be aesthetically pleasing and contain large-scale reminders of the historical ecosystem; such as flowing rivers and streams, and extensive and connected aquatic and terrestrial habitats; including salt marshes, tidal sloughs, and expanses of clean, turbid open water in the Delta. Fifth, ecosystems resulting from restoration priorities will probably be unlike any ecosystems that have previously existed. They will be made up of mixtures of native and non-native species that will interact in an environment where many basic processes have been permanently altered by climate change or human activity and continue to be regulated by humans. At the same time, the templates for the new ecosystems are the remnants of the original systems and the natural processes that made these systems work.

The process of setting goals for ecosystem restoration in the Focus Area requires an understanding of the historical complex of habitats and underlying processes and functions that once existed and those that currently exist. Such an understanding provides a basis for discussing the value of restoring historical functions within the contemporary landscape, identifying priority functions and locations for restoration, and determining measures of success for restoration. Knowing what important habitats existed historically, and where they existed, provides a potential blueprint for more effective development of large-scale restoration strategies that are more likely to be successful in providing the desired functions, particularly those supporting species of interest and biological community interactions. For example, habitat mosaics that mimic historical conditions may be critical for providing food-web productivity, balancing predator-prey interactions, and developing landscape connectivity to support native species. Given the strong influence of non-native fauna in the Focus Area, moving toward a landscape that is more similar to that in which species of concern evolved may increase their competitive ability. The historic strong seasonality, multiple physical gradients, and habitat complexity of the Focus Area provided a particular evolutionary setting to which native species adapted. Moving toward this type of landscape in the future would likely give native species an advantage.

Ecosystem restoration goals help develop and organize the numerous components of ERP. ERP's goals provide the basis for a programmatic-level vision of a desired future condition within the Focus Area. The goals are not intended to change over time except with significant change in policy direction or new scientific information. Each of the six ERP goals is interrelated. Often, an accomplishment towards one goal provides benefits for others. The goals were developed by a diverse group of representatives from CALFED agencies, academia and the stakeholder community. The six goals are as follows:

GOAL 1. RECOVER ENDANGERED AND OTHER AT-RISK SPECIES AND NATIVE BIOTIC COMMUNITIES: Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species. Support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

GOAL 2. REHABILITATE ECOLOGICAL PROCESSES: Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing[1] human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

GOAL 3. ENHANCE/MAINTAIN HARVESTED SPECIES: Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

GOAL 4. PROTECT, RESTORE, AND/OR ENHANCE HABITATS: Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

GOAL 5. PREVENT/CONTROL NON-NATIVE INVASIVE SPECIES: Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.

GOAL 6. IMPROVE/MAINTAIN WATER AND SEDIMENT QUALITY: Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

1. "Minimal ongoing human intervention" is not intended to limit existing restoration effort. It seeks to focus on future restoration so that its values are maintained with minimal additional effort.

Lessons Learned in Stage 1 and Management Considerations for Stage 2

The ERP Implementing Agencies began reviewing the progress of ERP project implementation annually from 2004 through 2007. Information was also collected from the activities of the CALFED agencies that contributed to ecosystem restoration, as these related to making progress toward implementing ERP goals during Stage 1. Additional information about programs or projects that were not part of CALFED activities, but contributed to the implementation of the goals, was used in the review as well.

The extended length of time needed to achieve the desired endpoints stated in the ROD— such as establishing new populations of native plant species, restoring emergent marsh habitat, creating optimum habitat conditions for covered species, determining flows necessary to support all life stages of native fishes, quantifying the ecological impacts of sediments, and determining the ecological significance of pesticide discharges — was recognized from the onset of the ROD. It is now also recognized that the ROD, as it was implemented, only partially addressed the full array of complexities within the Delta ecosystem and what is required to conserve them. As with any long-term project, lessons can be learned and used to inform future management decisions.

What could be done differently?
Initial implementation projects were envisioned to create changes to the complex and variable Delta ecosystem, but the timeframe necessary for these changes to be realized was much longer than the seven-year timetable established for reporting on the Stage 1 actions. Communication of this to the Legislature, Executive Office, and public needed to occur sooner in the process.

Related to this, initial implementation of ERP needed to be more focused on accomplishing the results many people were anticipating. Many projects were identified, but budget shortfalls, staff reductions, and planning realities hampered their execution. Additionally, measuring baseline conditions, assessing habitat needs, and identifying the factors limiting habitat were important initial activities that needed to be completed prior to launching restoration implementation.

For most projects, the State was not prepared for ERP granting needs. Many of the planning, development of regulatory documents, environmental compliance and permitting, monitoring, or scientific research efforts funded in Stage 1 were portions of multi-phased projects which required more than a single three year grant to see it through to completion. Many did not receive the necessary follow-up grants in a timely manner and often the timeframe between approval of a grant concept and implementation took more than one year. These and other granting difficulties led to exceeding critical timeframes and adding additional delay to initial project implementation.

What has been done well?
The undertaking and expectations of CALFED and ERP are immense. The development of conceptual models, a shared vision for ecosystem restoration, and a regulatory framework are a few of the tools ERP employed for ecosystem restoration and species recovery. These tools, along with the cooperation between agency staff and stakeholders in an open and transparent process, established through the Bay-Delta Public Advisory Committee and continued in the DSC public meetings; provides support and accountability for ERP. Further integration of science provides the necessary foundation for subsequent decision-making.

Complementary to these tools is knowledge of the historical condition of the Focus Area. Information on historical elevations and flows provides essential information about past and existing conditions. The use of forward-thinking in planning at the outset, and development of extensive information on current and historical ecology have been key elements sustaining ERP ecosystem management.

How is program progress measured?
In Stage 1, ERP tracked the outcomes of identified actions using 119 milestones, essentially a location-specific set of ERP actions focused on contributing to the recovery of endangered and threatened species. At the end of Stage 1, ERP evaluated program elements using the milestones. In Stage 2, program elements will be evaluated by the use of performance measures. Performance measures are used to assess the progress of program goals using quantifiable indicators. They are a vital part of an adaptive management approach, providing useful information about areas of success as well as weakness and they assist in identifying critical areas needing adjustment. Utilization of successful performance measurement promotes expenditures of limited resources to the highest program priorities, maximizing progress and minimizing waste, ultimately helping to ensure that outcomes meet expectations. Performance measures are discussed in Section 4: Adaptive Management. The performance measures discussion in this report is designed to give examples of how to assess the ability of new restoration projects and related resource management activities to support and fulfill ERP goals and objectives. The process of refining the measures will include scientific peer review and coordination with other ongoing restoration planning efforts in the region, including the Delta Plan and Bay Delta Conservation Plan (BDCP), to maximize regional effectiveness.

Other Considerations for ERP

Funding ERP Activities
It is essential for funding to be reliable throughout the course of Stage 2 (2008 - 2030) in order to achieve ERP goals and conservation priorities. ERP has utilized both Federal and State funding sources in the past including cost sharing between agencies.

Federal Funding. Federal Bay-Delta funding contributes to ERP goals through various agencies, programs, partnerships, operations, and direct habitat restoration projects.

Federal funding has varied by Federal fiscal year and provided funding in whole or part for projects that meet ERP goals.

State Funding. State funding for ERP has primarily been achieved through the passage of propositions. The primary sources of State funding for ERP projects have included the following:

- Proposition 204 - Safe, Clean, Reliable Water Supply Act (1996)
- Proposition 13 - Safe Drinking Water, Clean Water, Watershed Protection, and Flood Protection Bond Act (2000)
- Proposition 50 - Water Quality, Supply and Safe Drinking Water Projects Act (2002)
- Proposition 84 - Safe Drinking Water, Water Quality and Supply, Flood Control, River and Coastal Protection Bond Act (2006)

Future ERP Funding. Future State and Federal funding availability for implementing projects that meet conservation priorities identified in this Strategy is uncertain. Additional State bonds would probably need passage in order to sufficiently fund such projects. Federal funding sources and possible quantities remain unknown, although numerous efforts continue in the Bay-Delta, including projects associated with the Central Valley Project Improvement Act (CVPIA); the Environmental Quality Incentive Program and Wetland Reserve Program managed by the National Resource Conservation Service; and projects associated with Section 6 of the Endangered Species Act (ESA).

ERP Project Implementation

ERP uses several processes to achieve its goals and conservation priorities. One method is to award projects through a Proposal Solicitation Package (PSP). The PSP process allows for an open solicitation, rigorous technical review, and public input. Solicitations are created to identify and award projects targeted at achieving ERP goals and objectives.

Though the PSP process is an important aspect of how ERP awards projects; it alone is not sufficient. The proposals do not always include all the specific investigations necessary to resolve critical uncertainties, or scientific actions necessary to meet critical or time-dependent objectives. Given the scope and complexity of some of the issues facing the Focus Area, it may be necessary to supplement the call for proposals with support for additional (sometimes sustained) commitments of effort. Addressing critical information needs may require soliciting specific study approaches or projects that fill gaps of strategic need, or ERP may be approached by those with projects that can help fill these gaps. These projects, after having been reviewed and recommended by the ERP Implementing Agencies, can be awarded through a “directed action” process and/or be recommended for funding to the CDFW Director.

Incorporation of Uncertainty

The concept of uncertainty and its role in adaptive management is threaded throughout this Conservation Strategy. Uncertainty as described in this document includes the following: 1) the inability to predict the future state of dynamic systems, 2) the degree to which future conditions depend on unpredictable or unforeseen external drivers, 3) incorrect or incomplete information about underlying processes that make predicting outcomes difficult, or 4) disagreement about the underlying processes based on alternative interpretations of data. Uncertainties in ecosystem management are compounded by unknowns in our future conditions related to climate change, population growth, water supply needs and availability, and the likelihood of catastrophic natural events (e.g., earthquakes). Uncertainty is pervasive and absolute solutions are unlikely to be found. However, science will continue to be a main source of information for policymaking. Good science provides a reliable knowledge base for decision-making, but for complex environmental problems, new areas of uncertainty arise. Building and maintaining a scientific infrastructure to help meet future challenges is essential to any sustainable way forward for ERP. An approach that integrates science more fully into policy implementation would allow better and timelier assessment and inclusion of knowledge about how the system is responding. Adaptive management seeks to accomplish this integration (CALFED 2008).

Climate Change

CDFW's vision for responding to climate change challenges includes three major components, each of which are important to the success of effectively confronting climate change: 1) Unity - creating and maintaining vital climate change partnerships and collaborations, 2) Integration - integrating climate change into CDFW activities, and 3) Action - meeting conservation objectives for maintaining healthy ecosystems with regard to climate change impacts (DFG 2011c).

CDFW is committed to minimizing negative effects of climate change on the state's fish, wildlife, and habitats through the development of adaptation and mitigation measures, policies, and practices that provide clear benefits to terrestrial and marine ecosystems while recognizing the uncertainty associated with future climatic states. Emerging climate change science brings uncertainty and ERP recognizes that more studies need to be undertaken to understand how climate change issues will affect the Focus Area. Profound changes are likely, but the timeframe of these effects are not well understood. The impacts to the ecosystem of the Delta and Central Valley are anticipated to be prodigious and ERP recommends that specific studies and analyses be undertaken to tie climate change assessments to potential impacts within the Focus Area. ERP also recognizes the importance of developing and maintaining partnerships to more effectively address the broad scope of climate change issues.

Integration and Relationship of the Conservation Strategy to Other Planning Efforts

Several concurrent planning efforts are evaluating the status of the Focus Area resources. These evaluations include both the future use of those resources, and the risk to those resources from controllable and uncontrollable drivers of change. The Conservation Strategy informs and was informed by these efforts and information exchange will continue as respective planning efforts continue or are carried out. Appendix B provides a brief description of the numerous planning efforts that have been important to the development of this Conservation Strategy.

The ERP Implementing Agencies participated in the development of the ecosystem component of the Delta Vision Strategic Plan. During this process the Delta Vision Blue Ribbon Task Force recommended that the Conservation Strategy be the foundation of what will ultimately become the ecosystem component of several regional conservation plans. Some significant sources of information considered in development of the Conservation Strategy include:

Bay Delta Conservation Plan. CDFW is a permitting agency under the Natural Community Conservation Planning Act (NCCPA). To assure that the BDCP conforms to requirements of the NCCPA, CDFW is actively involved in providing policy, technical guidance, and support to that planning effort. The stated purpose of the BDCP will be to create a regulatory framework that both conserves at-risk native species and natural communities in the Delta and provides water supply reliability. CDFW is working with BDCP staff to ensure program activities support NCCPA requirements for species recovery and habitat enhancement in the BDCP.

The USFWS and NMFS are permitting agencies under the Federal ESA. To ensure there is adequate minimizing and mitigating of effects of any authorized incidental take, both agencies are participating in BDCP processes to provide technical assistance to the State of California in its effort to complete planning and permitting for a Habitat Conservation Plan as identified under sections 10(a)(2)(A), 10(a)(2)(B) and 10(a)(1)(B) of the ESA.

The Delta Conservancy. The 2009 Delta Reform Act created the Conservancy to act as the primary state agency to implement ecosystem restoration in the Delta. The Conservancy is also directed to support efforts that advance environmental protection and the economic wellbeing of Delta residents. The Conservancy is governed by a 23-member Board, including 11 voting members, 2 non-voting members, and 10 liaison advisors. The Conservancy is required by statute to complete and adopt a strategic plan by March 2013 (Delta Conservancy 2011). The Conservancy has developed its Strategic Plan, which will guide the Conservancy's projects and activities.

Delta Stewardship Council. The Delta Stewardship Council (DSC) was created by the Delta Reform Act to adopt and oversee implementation of a comprehensive management plan for the Delta (Delta Plan). The Delta Plan will be used to guide state and local actions in the Delta in a manner that furthers the co-equal goals. The Delta Plan also includes performance measurements that will enable the DSC to track progress in meeting the objectives of the Delta Plan. A state or local public agency that proposes to undertake certain actions within the boundaries of the Delta or the Suisun

Marsh is required to prepare and submit to the DSC written certification of consistency with the Delta Plan.

Flow Criteria Reports. The Delta Reform Act of 2009 required the State Water Resources Control Board (SWRCB) to develop flow criteria for the Delta by 2010 and for CDFW to develop flow criteria and quantifiable biological objectives for aquatic and terrestrial species of concern in the Delta also by 2010. Additionally, the Delta Plan currently being developed by the DSC requires that the SWRCB develop instream flow criteria for high priority rivers and streams in the Delta watershed by 2018. Since completion of the flow criteria reports (DFG 2010b, SWRCB 2010a), CDFW has continued to work with the SWRCB to identify new instream flow studies for the high priority rivers and streams in the Delta watershed and on the SWRCB's effort to develop flow objectives for the lower San Joaquin River.

NOAA Fisheries Central Valley Salmon and Steelhead Recovery Plan (CVSSRP). The ESA requires that recovery plans be developed for each species on the Federal list of threatened or endangered species. NOAA Fisheries' recovery planning process for federally listed anadromous salmonids in the Central Valley resulted in formation of a recovery plan team in 2007 that developed a Public Draft Recovery Plan (NMFS 2009b) that was released in October 2009. A Final Recovery Plan is expected to be released in 2013. This document will be a key resource for helping to achieve ERP goals. Additional information can be found in Appendix B.

USFWS Delta Native Fishes Recovery Plan (DNFRP). Eight fish species were included in the USFWS' Sacramento-San Joaquin Delta Native Fishes Recovery Plan (USFWS 1996): the delta smelt, longfin smelt, Sacramento splittail, green sturgeon, spring-run, late fall-run and San Joaquin fall-run Chinook salmon and the Sacramento perch. These eight species depend on the Delta for a significant segment of their life history. Threats to these species include loss of habitat due to increased freshwater exports resulting in increased salinity, loss of shallow-water habitat due to dredging, diking and filling, introduced aquatic species that have disrupted the food chain, and entrainment in State, Federal and private water diversions. State and Federal water projects were also identified as threats due to their changing of the pattern and timing of flows through the Delta. The salmon races are affected by sport and commercial harvest as well as by interactions with hatchery stocks. Action needs were identified as the following:

- Enhance and restore aquatic and wetland habitat in the Sacramento-San Joaquin River estuary
- Reduce effects of commercial and recreational harvest
- Reduce effects of introduced aquatic species on Delta native fishes
- Change and improve enforcement of regulatory mechanisms
- Conduct monitoring and research on fish biology and management requirements
- Assess recovery management actions and re-assess prioritization of actions
- Increase public awareness of importance of Delta native fishes

Subsequent to release of this recovery plan in 1996, the USFWS has made recent additional determinations related to the delta smelt, longfin smelt and Sacramento splittail that can be found in Appendix B.

These planning efforts share the goal of recovering at risk species. As such, the effectiveness and chances for successful restoration of species increases by aligning priorities and coordinating possible actions. The ERP Implementing Agencies will strive for such coordination and leverage the areas where priorities overlap in order to recover Focus Area species.

Overlapping Goals

There is a direct connection between ERP goals outlined in this strategy, the goals included in other planning efforts, and the continued implementation of projects and actions to achieve a shared vision for the Delta and its watersheds. Table 1 compares goals found in ongoing planning and restoration efforts with ERP's goals. It is understood that actions to implement goals and objectives of other planning efforts may not match actions envisioned to implement goals and objectives of ERP. However, many of these goals and objectives themselves seem consistent with or complementary to those of ERP; essential to achieve a strong long-term approach for restoration.

Table 1: Comparison of ERP goals with the goals and objectives found in other conservation and restoration plans for the Sacramento-San Joaquin Delta.[1]

ERP GOALS	BDCP	FLOW CRITERIA REPORT	CVSSRP	DELTA PLAN	DNFRP
Goal 1. Recover endangered and other at-risk species and native biotic communities	x	x	x	x	x
Goal 2. Rehabilitate ecological processes	x	x	x	x	x
Goal 3. Enhance/maintain harvested species	-	x	x	-	-
Goal 4. Preserve, restore, or reconcile habitats	x	x	x	x	x
Goal 5. Prevent/control non-native invasive species	x	-	x	x	x
Goal 6. Improve/maintain water and sediment quality	x	-	x	x	x

[1] BDCP (2012), Quantifiable Biological Objectives and Flow Criteria for Aquatic and Terrestrial Species of Concern Dependent on the Delta (Flow Criteria; DFG 2010b), Central Valley Salmon and Steelhead Recovery Plan (CVSSRP; NMFS 2009b), Delta Plan (DSC 2012), USFWS Delta Native Fishes Recovery Plan (DNFRP; USFWS 1996). "X" = a similar goal or objective present; "-" = no shared goal or objective.

Ecological Setting and Vision for Restoration of the Delta and its Watershed

The Central Valley, which includes the Delta and its watershed, encompasses 18 counties the most northern being Shasta County and southern being Kern County. The entire Central Valley is approximately 450 miles long and is between 40-60 miles wide. The region comprises most of the low-lying lands in Central California. The Delta ecosystem and its watershed receive 40 percent of California's surface water. The freshwater from the Sacramento and San Joaquin Watersheds flows into the Delta where it mixes with salt water from the ocean to create a unique, rich and diverse aquatic ecosystem. The Delta is a part of the largest estuary on the west coast of North America. Once a vast marsh described as a "terraqueous labyrinth of such intricacy that unskillful navigators have been lost for days in it" (Bryant 1848), the Delta has been transformed by over 100 years of levee building into a maze of interconnected waterways and low islands drained for agriculture.

The Delta provides valuable benefits to California's residents: it is the source of drinking water for over 25 million Californians, fuels a $37 billion agricultural industry, is a popular recreation area, serves as important habitat to more than 750 known animal and plant species, and supports 80 percent of California's commercial salmon fisheries (BRTF 2008).

Recent scientific findings indicate that the Delta ecosystem is under increasing stress. The well documented Pelagic Organism Decline (POD) as well as the number of listings of species as threatened or endangered is evidence of the declining state of the Delta and its watershed. Several factors, including habitat loss, invasive species, fish and productivity losses to water diversions, contaminants, and flow alterations have together gravely damaged the estuary. Effective restoration efforts are vital to ensure the Delta ecosystem continues to provide for all those who depend on it.

The ERP vision for the future restored Delta and its watershed does and should continue to align with many existing and future authorities, plans, policies and decisions. It includes expansive habitat heterogeneity, connected intertidal and floodplain habitats along rivers, the accommodation of natural geomorphic processes, and the provision of high quality habitats for native species. This vision necessitates acquisition of riverside properties, the setting-back or flattening of levees to enhance river meanders and restoration of erosion and deposition processes, and providing fish and wildlife access to floodplains. Restored habitats will reestablish a greater connection between land and water. This will facilitate the transport and exchange of sediment, nutrients, and organic materials that contribute to ecosystem complexity and productivity both locally and downstream. Restoration of riverine habitats and their functions is crucial to restoration of the Delta and its watershed. In particular, transmittal of sufficient upstream sediments to the Delta is essential for maintaining and restoring its intertidal and subtidal habitats.

The Delta is a component of a landscape that begins upstream in the headwater tributaries where water picks up minerals, sediments and nutrients as it flows towards and joins with the Sacramento River in the north and the San Joaquin River in the south. Both rivers historically meandered through the Central Valley before converging in the Delta. Once in the Delta, water from these rivers flows through its remaining expanse of channels and islands. Mixing occurs further downstream where fresh water meets marine, developing a salinity gradient which begins in the upper most boundary of the San Francisco Estuary. When downstream in Suisun Bay, this mixing zone spreads broadly over the flats of Honker and Grizzly Bays creating large expanses of low salinity habitat. As outflows reduce and tidal forces have more of an effect, marine waters push the mixing zone upstream into the relatively narrow river channels of the western Delta, greatly constricting the area of low salinity habitat. Over time, outflow, gravitational flows, and tidal mixing carry water and nutrients to the Pacific Ocean.This process shows how the Delta ecosystem is influenced by, if not dependent upon, physical, chemical, and biological processes occurring upstream. Therefore, to provide successful restoration of the Delta, extensive complementary habitat restoration must also occur upstream in the watersheds.

Inflow from the San Joaquin and Sacramento rivers and outflow from the Delta should be sufficient enough to cue and facilitate upstream and downstream migration of fish through the Delta and stimulate other biotic and abiotic processes. Flows in the Focus Area should also support local movements of fishes and provide access to and movement among currently functioning and restored aquatic habitats. Natural flow and functioning habitat should improve physical conditions and food production for imperiled fish and wildlife species, reduce major stressors, and support all life stages of fish and wildlife in the Delta and its watershed. Implementation of this vision will support sustainable populations of fish and wildlife species in the Focus Area.

A system of functioning habitats is envisioned to protect a full range of natural communities where natural processes and ecological gradients are promoted and the connectivity between terrestrial and aquatic habitats is maintained and enhanced. These protected lands should be of sufficient size and quality to maintain native biodiversity and provide conservation benefits to native species. They should be located in areas that maximize connectivity between protected lands and other important habitats. With restoration, the Delta ecosystem will provide increased public opportunities for wildlife observation, fishing, hunting, and other activities in a manner that is consistent with maintaining the fish and wildlife values.

The following sections present the current ERP approach for ecosystem restoration that focuses mainly on aquatic habitats and species in the Delta and the Sacramento and San Joaquin Valley regions. Each section is organized by ERP goal and category of ongoing ecosystem restoration, including ecological processes, habitats, stressors (including water quality and invasive species), and species. In addition, the visions, targets, measures and actions found in the original ERPP, ERP Strategic Plan, and MSCS documents are incorporated by reference into this Conservation Strategy. Future additional or modified aquatic and terrestrial species needs and associated conservation activities will be addressed in future revisions of this Conservation Strategy. This Conservation Strategy and future strategies will incorporate applicable species recovery plans; Habitat Conservation Plans (HCP) and Natural Community Conservation Plans (NCCP); will appropriately incorporate other protection, restoration and management efforts like those identified in Appendix B; and will continue to be informed by a science based adaptive management process.

DEFINITION OF ECOSYSTEM RESTORATION

Ecosystem restoration as defined in this document is the process of facilitating the recovery of ecosystems that have been degraded, damaged, or destroyed. It is the actions taken in fragmented or degraded terrestrial and aquatic ecosystems that result in the reestablishment of natural ecological processes, functions, and biotic/abiotic linkages and lead to a sustainable, resilient, and healthy system that is integrated within its landscape under current and future conditions, taking into consideration the physical changes that have occurred in the past and the future impact of climate change and sea level rise (California Water Code Section 85066; Society of Wetland Scientists 2000; Society for Ecological Restoration 2004; USFS 2010). Ecosystem restoration as envisioned by the ERP does not entail recreating a specific historical configuration of the Delta environment; rather, it means re-establishing a balance in ecosystem structure and function to meet the needs of native plant and animal species, and natural communities (CALFED 2000c).

Restoration requires a long-term commitment of land and resources, and a proposal to restore an ecosystem requires thoughtful deliberation, systematic planning, implementation, and continued monitoring efforts. Restoration may consist of removing or modifying a specific stressor, and allowing ecological processes to bring about an independent recovery. For example, removing a dam or diversion allows the return of a natural hydrological regime with improved channel-floodplain connectivity. In more complex circumstances, restoration may also require the deliberate reintroduction of native species that have been lost, and the elimination or control of harmful, invasive non-native species to the greatest practicable extent. Often, ecosystem degradation or transformation has multiple, protracted sources, and the historical constituents of an ecosystem are substantially lost. Sometimes restoration of the degraded ecosystem is impeded, due to loss of critical components or processes. Each of these aims to initiate ecological restoration or facilitate the natural processes which will return the ecosystem to its intended function.

When the desired restoration outcome is realized, the ecosystem may no longer require external assistance to ensure its future health and integrity, in which case restoration can be considered complete. Nevertheless, the restored ecosystem often requires continuing management to counteract the invasion of non-native species, the impacts of various human activities, climate change, and other unforeseeable events. In this respect, a restored ecosystem is no different from an undamaged ecosystem of the same kind, and both are likely to require some level of adaptive management. As new knowledge is gained, management priorities will be adjusted to reflect the new knowledge. Although ecosystem restoration and adaptive management form a continuum and often employ similar sorts of intervention, ecological restoration aims at assisting or initiating recovery, whereas adaptive management is intended to continue the well-being of the restored ecosystem thereafter (Society for Ecological Restoration International Science & Policy Working Group, 2004).

SECTION 1: Sacramento-San Joaquin Delta Region

Background

The Delta is a network of natural and artificial channels and reclaimed islands at the confluence of the Sacramento and San Joaquin rivers. The Delta forms the eastern portion of the San Francisco Estuary, receiving runoff from more than 40 percent of the state's land area. It is a low-lying region where over the years sediment from the Sacramento, San Joaquin, Mokelumne, Cosumnes, and Calaveras rivers mingled with organic matter from upstream sources combined with that deposited by the estuaries marsh plants. The Delta covers 738,000 acres interlaced with hundreds of miles of waterways, with much of the land below sea level and it relies on more than 1,100 miles of levees for protection against flooding. Today, over 95% of the original 350,000 acres (550 mi^2) of tidal wetlands and many miles of historical tidal sloughs are gone, as is most of the riparian vegetation that once bordered the larger waterways. In its place, are a patchwork of agricultural "islands," straightened and deepened channels, riprapped levees, and the flooded remnants of former wetlands now too far underwater to allow the re-establishment of emergent vegetation (Whipple 2012). The historical Delta was comprised of three fundamental landscapes: flood basin, tidal island, and meandering rivers (Whipple et al. 2012).

Flood Basin: The flood basins landscape characterized the North Delta, where the fluvial-tidal interface, influenced by the topographic and geologic environment, allowed for unique hydrologic and habitat conditions. One defining characteristic was a broad zone of non-tidal freshwater emergent wetland that graded into tidal freshwater emergent wetland. These wetlands consisted of an almost continuous dense stand of tule, which reached heights of 10 to 14 feet. Perennial ponds and lakes held low elevation backwater positioned behind natural levees or at the upland edge. The wetlands were bordered either by riparian forests along natural levees of the major channels or seasonal wetlands, including alkali and vernal pool complexes and riparian stream "sinks" at the upland edge. The riparian forests of the historical Delta were broad, described as greater than half a mile wide in some places, and included morphological features such as crevasse splays (small alluvial fans formed where an overloaded stream broke through a natural levee and deposited its material on the floodplain). Due to the presence of large natural levees and broad zones with few or no channels, with long distances to tidal sources, much of the flood basin wetlands were at least seasonally isolated from the tides. This was a landscape that depended on sediment-laden flood flows in the wet season. Floodwaters included annual flows from smaller upland systems such as Cache and Putah creeks and, in some years, overflow of the Sacramento River. These floodwaters formed what many referred to as large lakes within the basins that often stretched for many miles and persisted for several months. In the summer, parts of the basins dried out, evidenced in part by the numerous fires cited in the early settlement period, but not enough to preclude tule growth.

Tidal Islands: The tidal islands landscape historically included roughly 200,000 acres of freshwater emergent wetland that was strongly influenced by tidal dynamics, such that the land was inundated by spring tides if not more frequently. The tidal nature of this landscape is reflected in channel characteristics. Channel density and sinuosity were greater than in less tidally dominated parts of the Delta. Fluvial inputs during floods impacted this landscape as well, often inundating whole islands. Unlike the flood basin landscape, natural levees were low and subsequently overflowed by tides and floods with greater frequency. These banks were characterized by similar wetland vegetation to that of the interior islands. Tule covering the river banks was a common description. However, the wetland vegetation within a significant part of this landscape appears to have been composed of relatively less tule in comparison to the flood basin landscape. Instead, willows, grasses, and even ferns as well as tule were described as dominant species within the marsh plain.

Meandering Rivers: The meandering rivers landscape encompassed the South Delta historically, including the area where the three branches of the San Joaquin River formed the large Union and Roberts islands. Here the fluvial-tidal interface was intersected by more significant topographic features than in other landscapes. This was related to factors such as soil type and the more dynamic nature of active channels at this tidal margin. This landscape, too, was flooded annually, but the many side channels and oxbow lakes may have caused the floodwaters to be routed and perhaps channelized in ways different from the flood basin landscape. Many channels served the dual purpose of carrying both tide and flood water. Some parts of the primary river channels, such as Old River near present-day Fabian Tract, were occupied by large woody debris and were popular salmon fishing grounds for Native Americans and early explorers. In comparison to the flood basin landscape, a greater portion of the natural levee riparian vegetation was composed of willows and other brush, and some areas appear to have had open oak woodlands. As a reflection of the temporal and spatial complexity of the landscape, habitat patch sizes are thought to have been much smaller than in the other landscapes, with grassland, freshwater emergent wetland, seasonal wetlands, and intermittent and perennial aquatic habitats forming a complex mosaic at the tidal-fluvial edge. Tule dominated the freshwater emergent wetlands and became more continuous toward the lower and more tidally-influenced parts of the landscape.

I. Ecosystem Processes

The Ecosystem Restoration Program Goal 2 (Ecological Processes) is to rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities (CALFED 2000c). The Ecosystem Restoration Program Plan (ERPP) identifies several ecological processes which shape the system through direct, indirect, and synergistic means. The most notable processes affecting conditions in the Delta are: 1) hydrodynamics and hydraulics – including the amount and timing of flow entering the Delta from rivers and tributaries and the movement of water within Delta channels as affected by ocean tides, channel geometry, diversions, and barriers; 2) channel-forming processes – including floodplain connectivity and inundation, coarse sediment supply, channel bathymetry and heterogeneity; and 3) the cycling and transport of nutrients and aquatic organisms through the aquatic food web (CALFED 2000c).

Central Valley Streamflows (Freshwater Flows). The amount and timing of freshwater flow is an important feature of ecological processes and aquatic habitats in the Delta. In its natural, unaltered state, an estuarine ecosystem adapts to water flow variations; generally, high river flows have been linked to greater abundance of harvested species in other estuaries (Healey 2007 and references therein). Inflow to and outflow from the Delta presents challenges in ecosystem water management because the system has been significantly altered over the last century. However, it is still hypothesized that a variable flow regime, where flows vary by season to more closely mimic the natural hydrograph would likely favor native species which have evolved life history characteristics that respond to seasonal flow patterns (Moyle and Bennett 2008, Moyle et al. 2010, Baxter et al. 2010). Likewise, it is believed that managing a variable flow regime would eliminate the static nature of Delta aquatic habitats that have been sustained for decades in the interest of maintaining a common freshwater pool year-round for water exports, a regime that tends to favor non-native species and influence many other environmental factors. Therefore, it is important for scientists and managers to look for ways to provide adequate flows in existing and future Delta configurations that appropriately mimic a more natural flow regime to achieve desired ecological responses, rather than strive to completely restore the system to historical conditions. Further research is required to determine the characteristics of a variable flow regime. Flow parameters such as magnitude, duration, timing, frequency, rate of change, spatial gradient and salinity levels, need to be determined accompanied by careful monitoring, adaptive management of water operations and habitat restoration, and additional analyses that permit regular review and adjustment of strategies as knowledge improves.

Although the amount and timing of freshwater flow required to support a healthy estuary is still being studied and is under discussion, the net flow direction pattern and availability of associated tidal habitats should more closely resemble that available under the natural hydrograph with sufficient freshwater flowing westward towards the sea and not southward towards the Delta export pumps. Furthermore, what may be needed is a fall or early winter pulse that emulates the first “winter” runoff event, and higher late winter and spring flows that coincide with or better mimic historical conditions such as the melting of winter snow. Such a regime would provide attraction cues for anadromous fish moving upstream, improve survival of juvenile Chinook salmon and pelagic fishes rearing in the Delta, and provide downstream passage for fish moving through the Delta. In conjunction with improved channel configuration that connects channels to floodplain marshes and increases water residence time in some areas, these enhanced flows could improve food productivity and transport through the Delta to downstream areas. Improved flows should also reduce potential toxic effects of contaminants, transport sediment, and promote expansion of riparian vegetation. These improved flows are particularly important in normal and dry years, because human demand for freshwater supplies for beneficial uses is higher in normal and especially dry years than it is in wet years, and results in more freshwater being diverted from the system.

Moyle et al. (2010) presents key points for developing a Delta flow regime. They include considering not only the volume of inflows and outflows but the frequency, timing, duration, and rate of change of flows, as well as the occurrence of overbank flows. Flows and habitat structure are often mismatched and favor non-native species. It will be imperative to better understand the appropriate interaction between flow and habitat which favors native species over the non-native species. Effects of flow on transport and habitat are controlled by the geometry of the waterways. Channel geometry will change through time, so flow regimes needed to maintain desired habitat conditions will also need to change through time. Delta inflows affect habitat and biological resources in three different ways: floodplain activation, in-Delta net flows and transport, and Delta outflows. A strong science program and an adaptable management regime are essential to improving flow criteria. Long-term research to develop the next generation of models linking hydrodynamics and population dynamics, along with life cycle models is crucial for refining flow criteria. Monitoring alone is inadequate; peer-reviewed scientific studies of ecological processes are essential to provide guidance on how functions change with climate change, changing geomorphology, island flooding, habitat restoration, new flow-control structures, emerging contaminants, and new invasive species. Scientific synthesis must integrate results and make scientific insights useful for policy purposes.

The SWRCB and CDFW have recently assessed Delta flows (SWRCB 2010a and DFG 2010b) and developed flow criteria for the Delta and its tributaries. Additionally, the SWRCB has begun a process to review and update water quality objectives and the program of implementation will be included in the Water Quality Control Plan for the Bay-Delta. In doing so they have developed a Draft Technical Report on the Scientific Basis for Alternative San Joaquin River Flow and Southern Delta Salinity Objectives detailing the scientific basis for their flow recommendations (SWRCB 2012a). The SWRCB anticipates implementing the flow objectives through water rights actions, water quality actions (e.g., Federal Energy Regulatory Commission [FERC] hydropower licensing processes), and actions by other agencies.

Bay-Delta Hydrodynamics. At the outset of ERP implementation, available data indicated that returning Delta hydrodynamics to conditions present in the mid-1960s would enable better movement of sediments, nutrients, and the egg, larvae, and juvenile life stages of native Delta fishes, in addition to improving migration cues for anadromous fish moving through the Delta (CALFED 2000a). Specifically, it was recognized that factors such as the CVP and the State Water Project (SWP) export pump operations, the Suisun Marsh Salinity Control Structure (SMSCS), the Delta Cross Channel (DCC), and other flow barriers in the Delta created unnatural flow patterns with respect to water movement, velocity, and salinity. Research and monitoring conducted since 2000 continue to support this understanding of flow patterns, but also demonstrate that other factors (e.g., species introductions) can modify flow/species relationships. There are numerous references in the Delta Vision Strategic Plan, and other efforts regarding the need to restore the historical dendritic channel system in the Delta. Controlling water flows and fish movements at some of the current circular Delta channel connections should prevent anadromous fish from being diverted into areas of the Delta where their mortality may be increased due to entrainment at the south Delta export pumps or predation in the central Delta. However, before implementing such actions their overall effects to these and other Delta fishes should also be evaluated first.

Increased water residence time is also expected to enhance production of algae and aquatic invertebrates that comprise the food sources for different life stages of numerous native fish species. However, there are cautions that must be employed when managers consider manipulating flows through the use of barriers to facilitate certain ecological processes. Specifically, since the Delta is a nutrient-rich estuary, closing existing connections to increase water residence time can adversely impact water quality (e.g., resulting in eutrophication, a condition in which accumulation of nutrients supports a dense growth of algae and other organisms, which depletes shallow waters of oxygen during decomposition in summer) and the movement of aquatic species (Monsen et al. 2007).

Several internal Delta hydrodynamic parameters, including net delta outflow, net flow in Old and Middle rivers (OMR), Rio Vista flow, and QWEST (the net flow in the lower San Joaquin River), are among the measures referred to by fishery managers when assessing the favorability of Delta hydrodynamic conditions for fish migrations.

Recent analyses have revealed that the direction and magnitude of flows in south Delta channels are good predictors of fish salvage at the SWP and CVP export pumps (Grimaldo et al. 2009). Net reverse flows in OMR in winter months - a function of decreased San Joaquin River flow into the Delta, export pumping rate, and tides - is correlated with the salvage of adult delta smelt (USFWS, 2008a) and has recently been moderated (i.e., made less negative) to minimize the entrainment effects of SWP and CVP export pumps. Some modeling studies demonstrated a probable effect of net upstream flow on free-floating delta smelt larvae (Kimmerer and Nobriga 2008), leading to additional constraints on OMR flow to minimize impacts on larvae and juvenile delta smelt. OMR flow requirements were included in the recent Operations Criteria and Plan (OCAP) Biological Opinions (USFWS 2008 and NMFS 2009a).

Sacramento River flow at Rio Vista provides an important cue for adult Chinook salmon migration (Stein 2004), and the SWRCB Bay-Delta Water Quality Control Plan contains a flow objective at Rio Vista. Sacramento and San Joaquin rivers flows have also been identified as important factors for juvenile Chinook salmon survival during emigration from these basins (Newman and Rice 2002, Newman 2003, Newman 2008).

Net flow (i.e., flows adjusted for tides) in the lower San Joaquin River in the western Delta (QWEST) has been used in past biological opinions to define conditions necessary for successful juvenile Chinook salmon migration (i.e., survival) through the

Delta. The QWEST parameter may also be pertinent to delta smelt and other species (NMFS 1993). A strongly positive QWEST is used as an indicator of successful transport of longfin smelt larvae out of the lower San Joaquin River and into Suisun Bay; conversely, a negative QWEST suggests a high risk of entrainment into the south Delta (Randall Baxter, pers. comm.).

Hydrologic models for the Delta developed by several planning efforts helped identify the hydrodynamic processes important to the survival of fish. ERP funded the development of an ecological flows modeling tool for the Sacramento River during Stage 1 (SacEFT), and has recently provided additional funding to develop a similar modeling tool for the Delta. As part of its activities in development of the BDCP, Department of Water Resources (DWR) is developing a water operations model that will include anticipated sea level rise and flooding regimes, as well as their implications for ecological processes in the Delta. Until these models are available, however, recommendations for a flow regime are based on a combination of historical relationships; tools such as DWR's California Statewide Integrated Model (CalSim), Delta Simulation Model II (DSM-2), Delta Risk Management Strategy (DRMS), TRIM3D, and RMA models; and professional judgment.

Synthesis of historical and new information has been and should continue to be used to develop a methodology for evaluating through Delta flow and hydrodynamic patterns. Peer review and evaluation of the methodology in the context of species life cycle models and the conceptual model for Delta flow must occur to develop and implement an ecologically based plan to restore conditions in the rivers and sloughs of the Delta sufficient to support targets for the restoration of aquatic resources. Use of appropriate life cycle and conceptual models will assist the preparation of an adaptive management strategy for implementation and assessment of actions.

Delta Outflow and X2. Water quality management of the Bay-Delta system is based in part on a salinity standard known as "X2" (SWRCB 1995). This standard is based on empirical relationships between the abundance or survival of various species of fish and invertebrates and X2 (the position in km from the Golden Gate of the 2 psu isohaline as measured near the channel bottom), or freshwater inflow to the estuary during a critical period in the organism's life (Jassby et al. 1995, Kimmerer 2002, IEP 2008). The location of X2 moves up and down the estuary on a daily basis in response to the tides. In general, X2 position in the estuary follows an annual cycle characterized by a more seaward position during the winter-spring high outflow period, and a more landward position in the relatively low flow summer-fall period. Requirements for the position of X2 are based on correlations with abundance of several Delta aquatic species in the winter and spring months, and are detailed in the SWRCB's Bay-Delta Water Quality Control Plan (SWRCB 1995). Also, the 2008 OCAP Biological Opinion includes an RPA component specifying the position of X2 in the fall following Wet and Above Normal water years.

Species X2 relationships have necessarily remained static over time (Kimmerer 2002, Kimmerer et al. 2009). Establishment of the overbite clam (*Potamocorbula amurensis*) in the mid-1980s generally reduced phytoplankton availability for zooplankton and zooplankton declined, reducing food supplies for young fish. Even since the establishment of *Potamocorbula* positive species responses to outflow remain, including a significant longfin smelt abundance/flow relationship,(Figure 2), indicating a continued strong benefit to longfin smelt as X2 moves down the estuary.

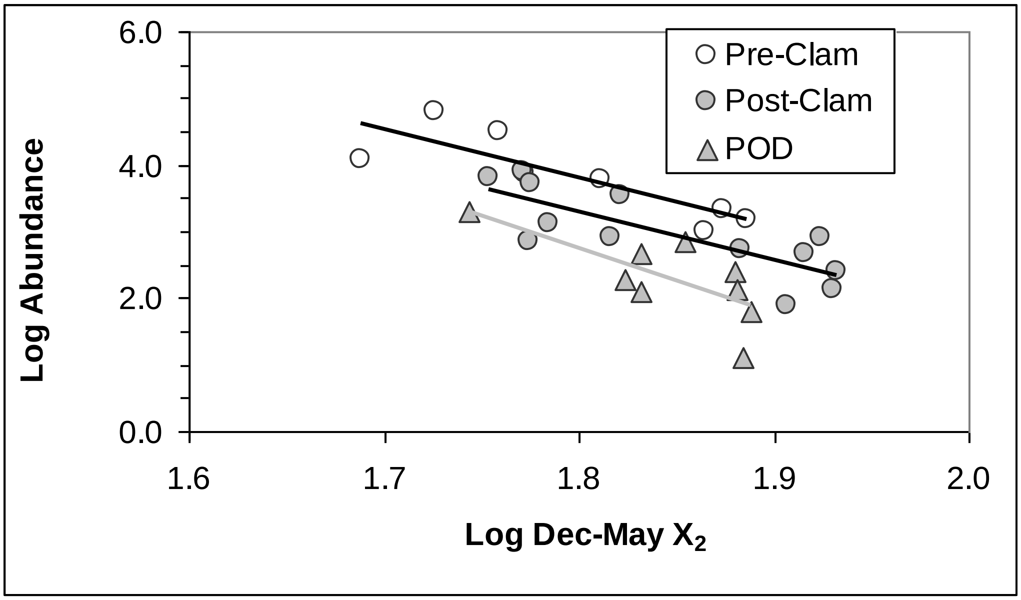

Figure 2: Longfin smelt Abundance-X2 Relationships for pre-*Potamocorbula* (open circles; 1980-1987), post-*Potamocorbula* (filled circles; 1988-2000) and POD years (filled triangles: 2001-2009). Black lines significant $p < 0.05$; gray line significant at $p < 0.10$. (Randall Baxter [CDFW, Region 3]).

Relationships between X2 and the abundance of a number of other species did not change after the establishment of *Potamocorbula* (e.g., bay shrimp, American shad, and splittail), but these relationships likely result from mechanisms occurring well upstream (American shad and splittail) or downstream (bay shrimp) of X2 (Kimmerer 2002). Research, monitoring, data analysis, and modeling continue to increase understanding of mechanisms underlying X2 relationships. Some recent research findings that have increased our understanding of X2 include:

- Declines in habitat suitability were reported in summer for delta smelt (Nobriga et al. 2008) and in fall for three species including delta smelt (Feyrer et al. 2007). For delta smelt the detrimental factors were increased water transparency (Secchi depth) and increased salinity, the latter likely due to reduced summer-fall river flow into the estuary largely due to increased water diversions following wet and above normal water years. Temperature did not have much predictive power in these analyses, likely because species presence or relative abundance only responded to temperature only when it neared or exceeded the presumed lethal limit, and this currently occurs for delta smelt.

- Kimmerer et al. (2009) evaluated the extent of habitat volume as a mechanism underlying the positive response of nekton to outflow in the San Francisco Estuary during spring. Their analyses indicated that neither changes in area or volume of low salinity water (habitat) account for this relationship for species showing relationships with X2, except for striped bass and American shad, two of the eight species they examined. They also found that longfin smelt habitat size varied inversely with X2 location. They did find that habitat volume in spring for delta smelt increased as X2 moved seaward.

- Feyrer et al. (2011) developed a model to predict delta smelt habitat quality in response to X2 (Figure 3). The model identified a reduction in overall September through December habitat quality as X2 location moves up the estuary. Data from several scenarios of climate change also predicted declining habitat suitability for delta smelt as climate change proceeds.

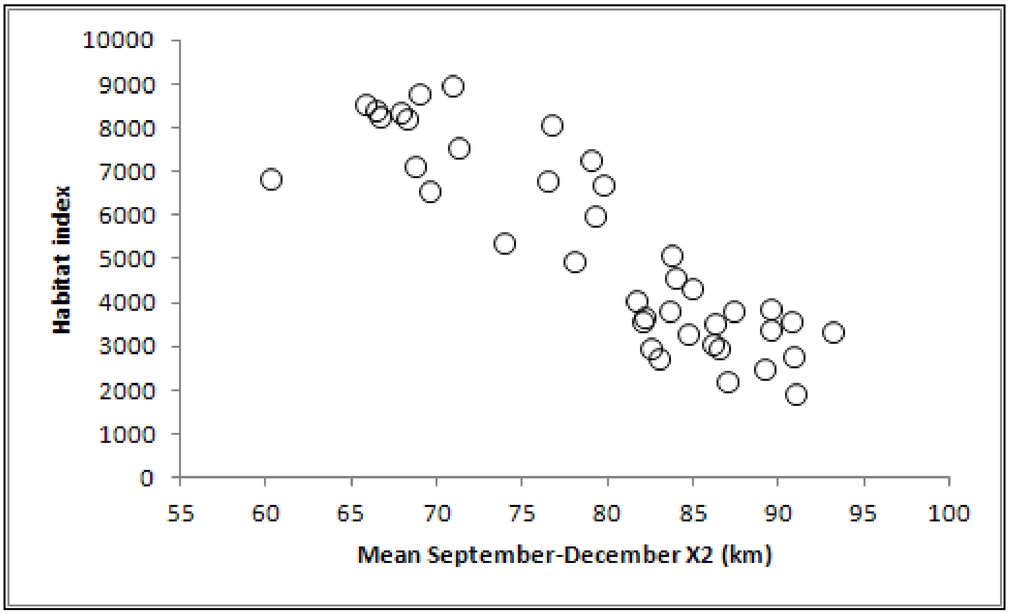

Figure 3. Delta smelt X2 Habitat Index Relationships to X2 locations in the estuary from the period September through December (Feyrer et al. 2011).

- Contra Costa Water District (2010) recently reviewed and summarized a wide range of historical reports and analyses regarding salinity in the western Delta and Suisun Bay. The basic conclusion was that a variety of human activities including channelization of the Delta, elimination of tidal marsh, construction of deepwater ship channels and diversions of water have contributed to increased salinity in the region. Consistent with fall X2 observations, the report also noted that fall salinity in 21 of the last 25 years has resembled that expected during a drought, even though half the years have been relatively wet. Although the operations of reservoirs and water diversions have been able to ameliorate the effects of salinity on water supply, salinities still exceed pre-1900 levels.

In summary, data and findings continue to support the conclusion that X2 location (i.e., outflow) is an important metric for the habitat (i.e., for recruitment success) of several native estuarine species. For some species, the likely mechanisms have been identified (e.g., splittail and floodplain inundation), but other mechanisms remain to be deciphered. Continued research will be crucial to evaluating the underlying mechanisms and better managing for X2-responsive species. The Bureau of Reclamation (Reclamation) has designed, and is now conducting, within the auspices of the IEP a comprehensive research and adaptive management plan related to the fall X2 component of the 2008 USFWS OCAP Biological Opinion. Also, USFWS biologists are currently collaborating with others on a detailed analysis intended to separate flow effects on longfin smelt from other factors, such as the *Potamocorbula amurensis* invasion.

Salinity. The historic Delta was freshwater dominated on an annual basis. Salinity varied seasonally and expanded further into the estuary in times of drought and further downstream in wet years. However, the actual "values" of these salinity placements for associated species compared to today's placements is uncertain considering the extensive changes to Delta configurations over time. Salinity is a principal water quality constituent affecting fish distribution in the estuary (Nobriga et al. 2008). Summer and fall salinity has been relatively high since 1985 and has diminished habitat quality for delta smelt in particular (Feyrer et al. 2007, Nobriga et al. 2008). The recent decline in fall outflow has led to increased and inter-annually less variable fall salinity in the western Delta and Suisun Bay since the 1987–1992 drought and especially during the POD years (Winder and Jassby 2010). Factors contributing to increased summer and fall upper estuary salinities include tighter management of export and inflow ratios (E/I ratios, i.e., Delta export and reservoir releases; IEP 2008).

Continuous heterogeneous environments have been found to be better able to absorb random disturbances and provide a variety of habitat types for fish and wildlife (van Nes and Scheffer 2005). The Envisioning Futures for the Sacramento-San Joaquin Delta report (Lund et al. 2007) found, "…*seasonal and interannual variability in much of the estuary may better mimic the natural salinity regime and help limit the extent of invasive species, which tend to prefer waters with little salinity fluctuation*". The report also stated, *"[A] Delta that is heterogeneous and variable across space and time is more likely to support native species than is a homogeneously fresh or brackish Delta. Accepting the vision of a variable Delta, as opposed to the more commonly held vision of a static Delta, will allow for more sustainable and innovative management*". Salinity fluctuations in the Delta may also help reduce invasive species such as Brazilian waterweed (*Egeria densa*).

Turbidity**.** Sediment transport influences the geomorphology, biogeochemical cycling, pollutant load, and ecology of river deltas and estuaries. In the Sacramento-San Joaquin Delta, turbidity is largely considered a surrogate of suspended sediment concentration, and has been declining over the past 30 years. This has contributed to dramatic changes in the ecology of the Delta and to the decline of the endemic and endangered delta smelt. The declining turbidity trend in the Delta has been attributed to reduced sediment inputs and expansion of invasive submerged aquatic vegetation (Hestir et al. 2010).

Channel-Forming Processes. Channel-forming processes include channel meander, natural floodplains and flood processes, and coarse sediment supply. They are connected to habitat complexity, fish community structure, food productivity and overall ecosystem health.

Natural Floodplains and Flood Processes. Several projects funded by ERP and other entities during Stage 1 have demonstrated beneficial effects of restoring floodplains for the dual purposes of flood control and ecosystem restoration. Specifically, studies on the Cosumnes River and Yolo Bypass floodplains showed that salmonids and splittail reared in these sites exhibited enhanced growth (and thereby, it is assumed, enhanced overall fitness for survival) relative to fish rearing in the Sacramento River. Feyrer et al. (2006) showed that salmon use floodplains and adjacent habitats from at least January through May, supporting the value of January through May inundation. Maintaining inundation for 30 days or more in the period of March through May would support recruitment of a large splittail year class, and adults would benefit from inundation starting in January (Moyle et al. 2004). Protracted inundation also allows time for primary production to occur. Sommer et al. (2004) showed that floodplains rapidly generate primary production and have the potential to export a portion of this productivity to downstream habitats. However, the magnitude and downstream food web effect of any productivity export remains to be determined. Another uncertainty is the extent to which seasonal floodplains create and/or transport methylmercury. Current research projects have been designed to determine floodplain restoration and management methods that will reduce methylmercury hazards. Methylmercury is ubiquitous to many watersheds feeding into the Delta; accounting and management of it must be addressed in all aquatic restoration activities.

Bay-Delta Aquatic Food Web. Aquatic food webs in the Delta are comprised of phytoplankton, zooplankton, and other organisms that provide food for larger organisms, such as fish. Primary producers include lower-order organisms such as phytoplankton and photosynthetic bacteria. Secondary productivity includes aquatic invertebrates such as rotifers, cladocerans, and copepods. Primary productivity is most important as a food source for pelagic aquatic invertebrates which in turn are an important source of food for early life stages of fish species in the Delta.

At the outset of ERP implementation, the northern San Francisco Bay and Delta had been experiencing a long-term decline in pelagic productivity, with a dramatic reduction following the introduction of the non-native overbite clam in 1986 (Kimmerer et al. 1994, Kimmerer and Orsi 1996, Lehman 1996, Jassby et al. 2002). Some, but not all, of the recent decline in productivity could be attributed to the introduction of overbite clam. The decline in productivity in the northern San Francisco Bay and Delta was accompanied by declines in several species of higher trophic levels, including mysid shrimp and longfin smelt, suggesting the possibility that recovery of some of these higher trophic level groups might be limited by food production at lower trophic levels.

Several uncertainties regarding the decline in productivity that were identified in the ERP Strategic Plan are still relevant, and are currently under investigation:

- How much of the decline in productivity is attributable to the overbite clam and what other factors may be affecting productivity?
- Is the decrease in productivity limiting recovery of higher trophic level species?
- How much effect would more frequent inundation of floodplains and bypasses have on estuarine and riverine productivity?
- Will restoration and/or enhancement of tidal wetlands, floodplains and riparian habitats, contribute to an increase in productivity and exchange with open water habitats?

Availability of food resources is a main factor contributing to fish abundance. Although phytoplankton production (as measured by Chlorophyll *a* concentration) makes up a small portion of the system's organic matter, studies show that it forms the base of the Delta pelagic food web (Jassby and Cloern 2000, Sobczak et al. 2002); therefore, a decline in primary productivity affects the entire food web.

Appropriate freshwater flow, channel geometry, water quality conditions, and floodplain inundation, in combination with tidal marsh restoration, are expected to result in a more productive aquatic food web by: 1) increasing water residence time in some areas (i.e., slowing water velocities will provide conditions more conducive to primary production), and 2) transporting more detritus and organic material from restored tidal habitats and into the Delta from floodplains after inundations. Recognizing the potential for some negative effects (e.g., mercury methylation and low dissolved oxygen if too much organic matter is drained into dead-end channels/slough), these processes, in conjunction with a substantial increase in tidal wetlands, could increase primary and secondary productivity in the Delta (Jassby and Cloern 2000).

Findings of ERP and Delta Science Program research have increased our understanding of the Bay-Delta aquatic food web. These findings include:

- Overbite clam continues to have a significant effect on the Bay-Delta food web and ecosystem (Kimmerer 2002, 2004). It has been suggested that overbite clam distribution may be managed by increasing freshwater outflows from the Delta into Suisun Bay in the spring to push distribution of the more brackish water endemic overbite clam further west of the Delta. However, there is no consensus among scientists about whether this is likely to be effective. While some scientists believe that repelling overbite clam for even a few weeks in spring could result in phytoplankton (diatom) blooms that could be utilized by copepods, others predict that these blooms would still be consumed by the clams, whose filter-feeding impacts extend far upstream of their physical distribution. It remains unknown whether overbite clam can be managed in this system, but many experts believe it cannot be (Healey et al. 2008).

- Copepods, which feed on diatoms and are a valuable food source for Delta fishes, are food-limited in the Delta (Kimmerer and Orsi 1996, Mueller-Solger et al. 2002, Sobczak et al. 2002), most likely due to depletion of diatoms by overbite clam grazing. The general conclusion from these studies is that growth or reproductive rate in copepods is severely impacted by food-limitation most of the time (DFG 2010e).

- The decrease in diatoms and in copepod recruitment due to loss of early life stages caused by overbite clam grazing has also had variable effects on species of higher trophic levels. Longfin smelt showed the greatest declines. Both longfin smelt and young striped bass were affected by the crash of *Neomysis mercedis* in the system (Feyrer et al. 2003). The abundance of delta smelt did not change following the introduction of overbite clam (Kimmerer 2004), although individual delta smelt were often food-limited (Bennett 2005), with a reduction in mean length that may result in reduced fecundity.

- Although the overbite clam has had a documented impact on the estuarine food web, it is unlikely the only cause of low productivity. At relatively low concentrations, ammonium in the lower Sacramento River and Suisun Bay can inhibit uptake of nitrate by phytoplankton and thereby eliminate phytoplankton blooms. Spring phytoplankton (diatom) blooms occur only when ammonium concentrations are less than 4 μmol/L (Wilkerson et al. 2006, Dugdale et al. 2007). At these low concentrations, the inhibitory nature of ammonium is relieved and diatom blooms fueled by the more abundant nitrate can occur. Diatom blooms typically occur following high spring flow events, when ammonium in the system is diluted and stratification of the water column increases light penetration (Cloern 1991), although presently the stratification must be maintained longer for diatoms to reduce the ammonium concentration to low enough levels to enable absorption of nitrate. During a high spring bloom, diatoms can temporarily out produce clam grazing in key Delta areas (Wilkerson et al. 2006), but a bloom in Suisun Bay occurred only once over the four springs from 2000 to 2003 due to stratification events of insufficient length to overcome the high ammonium concentrations. Werner et al. (2009) researched the toxicity of Sacramento Regional Wastewater Treatment Plant effluent and found that it was higher than would be expected based on ammonia/um content alone and they concluded that additional contaminants increase effluent toxicity to larval delta smelt.

- A study investigating the trends and causes of phytoplankton abundance concluded that the trend in primary productivity in the Delta between 1996 and 2005 has been positive and the trend in Suisun Bay was flat (Jassby 2008). This finding does not support the argument that fish declines observed during the early 2000s (Sommer et al. 2007) were caused by food limitation from additional reductions in primary production (phytoplankton); rather, it suggests that some other mechanism could be limiting food availability (e.g., contaminant toxicity to zooplankton). Ongoing studies seem to support the hypothesis that various chemicals released from wastewater treatment plants and agriculture have both chronic and acute toxic effects on zooplankton (Werner et al. 2009).

- Along with the toxicity to food web organisms, there has been a change in the composition of the Delta food web. In many cases, the most abundant food web organisms are introduced species. These new species compete with native species for resources, and some are often harder to catch, or are of lower nutritional quality than native food web organisms. As a result, the Delta's freshwater food web structure has changed in terms of primary productivity and carbon retention, and may not be as beneficial to the Delta's native species as it was previously.

Another mechanism under investigation is the connection between food web production and habitat. An ongoing ERP funded project in Suisun Marsh measured primary and secondary productivity and fish abundance and compared these to adjacent open water habitats. The comparison shows that the highly productive brackish tidal marshes provide important habitats to native fish; however, phytoplankton production in marsh channels appears to be limited when overbite clam is present. Recent studies have demonstrated that tidal marsh restoration would likely increase phytoplankton biomass in the estuary and enhance the planktonic food web. In a study of carbon types and bioavailability, tidal marsh sloughs had the highest levels of dissolved and particulate organic carbon and phytoplankton-derived carbon (Sobczak et al. 2002). Tidal sloughs were also the highest in Chlorophyll *a* concentration, an important factor in zooplankton growth rate (Mueller-Solger et al. 2002). Delta and Suisun Bay zooplankton appear to be food-limited much of the time, due to low levels of phytoplankton (Mueller-Solger et al. 2002, Sobczak et al. 2002, Kimmerer et al. 2005). It appears that high residence time of water, nutrient availability, and absence of non-native clams contribute to high levels of primary production (Jassby et al. 1995). Empirical studies (Lopez et al. 2006) suggest that productivity from high-producing areas, such as marsh sloughs, can be exported to other habitats.

Many studies have shown floodplains to be important to native fish, especially as rearing habitat for juvenile salmon and as spawning and rearing habitat for splittail. Recent research (Lucas et al. 2006) has shown that floodplains have much higher primary production than adjacent river channels and that much of this production is exported to downstream estuarine habitats.

In summary, changes to Delta habitats, flows and channel geometry; species introductions and increased contaminant loads (i.e., ammonium) have resulted in substantial changes to the food webs in both the Delta and Suisun Bay, and have limited phytoplankton blooms, respectively. Restoration actions that improve Delta primary production could help to increase zooplankton production and augment the pelagic food web. Such actions include increasing water residence times (e.g., creating deadend sloughs, floodplain inundation) to allow for phytoplankton accumulation, reducing inputs of ammonium and other contaminants by improving wastewater treatment practices, reducing agricultural chemical runoff through better farming practices, and restoring additional wetlands and tidal marshes to increase nitrification rates to remove ammonium from the system. All of these actions would require thorough planning to ensure the results can be achieved with minimal adverse effects.

Although much has been learned about the Delta food web since 2000, scientists remain uncertain about the importance of food limitation to native fishes. More studies are needed to resolve the uncertainty about whether primary productivity is limiting zooplankton and native fishes. The overbite clam had a demonstrably negative impact on the food web of Suisun Bay and the western Delta, the significance of which is still being investigated. It seems intuitive that enhanced zooplankton production in the Delta and downstream would provide better feeding conditions for fish; however, it's currently unclear whether any additional zooplankton productivity would reach fishes, before being taken by the overbite clam. Research supports tidal marsh restoration as a means of improving system productivity in brackish regions, but no large-scale restoration project has been completed or monitoring data synthesized that support this conclusion for the freshwater portion of the estuary. Floodplains have been shown to provide important habitat to native fish and to increase local productivity. Ongoing POD-related research will help to address some of the remaining uncertainties.

Water Temperature. The ERPP includes targets for Central Valley stream temperatures, including those that maintain specified water temperatures in salmon and steelhead spawning, summering, and migration areas during certain times of the year (CALFED 2000a). While mature riparian trees help lower water temperatures in the tributaries and may have some reduction effect in smaller Delta sloughs, water temperatures in Delta channels are driven by ambient air temperature and sufficient flows. Creation of tidal marsh areas in the Delta and Suisun and nighttime inundation of marsh plains might help lower water temperatures on a very small and localized scale. This potential cooling effect will require further investigation to evaluate the extent of effect it may have on Delta water temperatures.

Water temperature is a key factor in habitat suitability for aquatic organisms. Unnaturally high water temperature is a stressor for many aquatic organisms, particularly because warm water contains less dissolved oxygen. Lower water temperatures can also hinder growth and distribution of some non-native species, thus reducing their predation on, and competition for food and habitat with native species. Major factors that increase water temperature and negatively impact the health of the Delta are disruption of historical streamflow patterns, loss of riparian vegetation, reduced flows released from reservoirs, discharges from agricultural drains and climate change.

It may be difficult to manage water temperatures in the Delta because Delta water temperatures are driven mainly by ambient air temperature. With expected localized warming of air temperatures due to regional climate change, particularly in summer, the problem of maintaining sufficiently low water temperatures in the Delta to sustain native species will become more problematic. While creating patches of riparian habitat may help cool water in small Delta sloughs through shading, and creating tidal marsh habitat may help cool water locally through nocturnal inundation of marsh plains, managers should seek to facilitate fish access to the water temperature conditions they require if achieving those water temperatures in specific historic areas is no longer feasible. Provided adequate floodplain, channel margin and tidal habitat continue to exist, it is likely that individual species distributions will change during certain times of the year as they attempt to adapt to future conditions in the Delta.

II. Habitats

ERP Goal 4 (Habitats) is to protect, restore and/or enhance functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics. The ERPP identified a number of key habitat types for which conservation and restoration would be pursued in the Delta (CALFED 2001a).

All permanent aquatic habitats in the Delta are occupied by fish of some type. In planning for restoration of Delta aquatic habitats, it is important to consider which fish will occupy which habitat and when; and what type of benefits fish will gain from the habitat. Fish assemblages in the Delta, each with a distinct set of environmental requirements, include native pelagic species (e.g., delta and longfin smelt); freshwater planktivores, dominated by non-native species such as threadfin shad and inland silverside; anadromous species (e.g., salmon and steelhead); slough-residents associated with beds of non-native submerged aquatic vegetation (SAV) (e.g., centrarchide); and freshwater benthic species (e.g., prickly sculpin) (Moyle and Bennett 2008). Habitat diversity is necessary to support multiple fish assemblages in the Delta. Restoration efforts need to focus on creating habitats required by desirable species, while avoiding habitats dominated by undesirable species.

Development of the Delta Conservation Strategy Map. The Delta Conservation Strategy map identifies broad areas appropriate for habitat restoration within the Delta, primarily based on land elevations, and excludes areas with current urban zoning constraints (Figure 4). Existing non-urban land uses, infrastructure, and other constraints at these locations were not considered for this map. These features will be addressed in future analyses of site-specific proposals. The map presents existing elevations in the Delta as of 2011, which can provide a starting point for developing priorities for habitat restoration. Four categories of habitat relative to the current sea level are identified, including upland and transitional areas, inter- and subtidal areas, floodplains and open water areas. Appendix C provides a crosswalk between habitat categories in this Conservation Strategy for the Delta and those in the ERPP.

In accordance with the recommendations in the Delta Vision Strategic Plan and in light of expected sea level rise, the areas of the Delta that are of highest priority for restoration include lands that are in the existing intertidal range, floodplain areas that can be seasonally inundated, and transitional and upland habitats. Assuming a rise in sea level ranging from 30 cm to 45 cm by 2050 (Cayan et al. 2009), these areas would become shallow subtidal, seasonally inundated floodplain, and intertidal habitats respectively. The next highest priority for restoration would be lands below the intertidal range that are not highly subsided, and are within the range of feasibility for subsidence reversal projects. The lower elevation boundary of subsided lands appropriate for tidal marsh restoration has not been established, and may vary depending on location, configuration, availability of dredge spoils, and other factors that may promote or inhibit soil accretion associated with vegetation establishment. The most subsided lands would be the lowest priority for restoration to tidal marsh because raising elevations to the range appropriate for vegetation establishment is likely to be infeasible. However, these deeply subsided lands may have value as deep water habitat, although the potential benefits and liabilities of increasing deep water habitat in the Delta ecosystem have not been established.

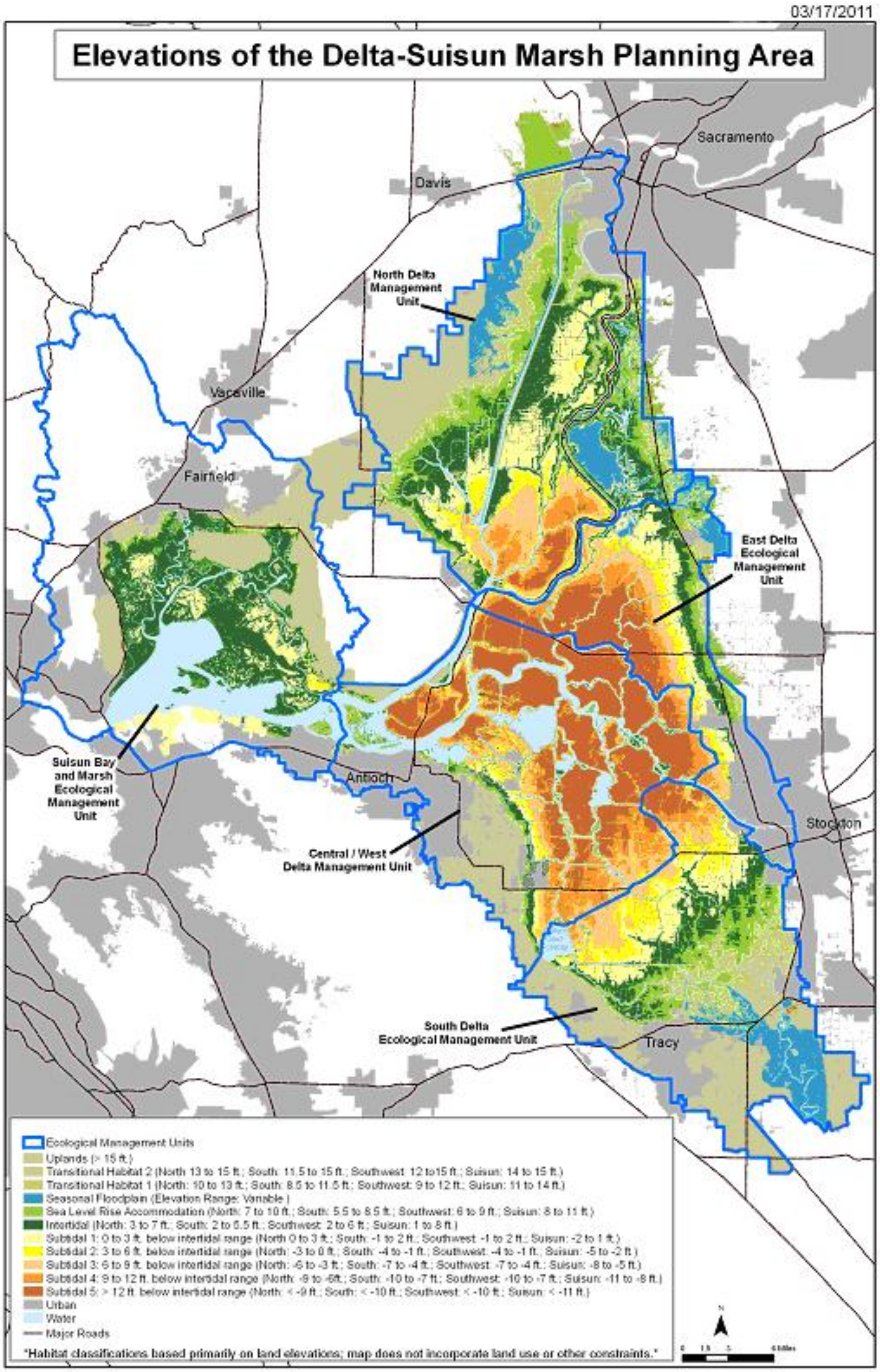

Figure 4: Land elevations in the Delta and Suisun Marsh. Current land elevations will largely determine what habitat types can be accommodated.

Essential Fish Habitat. The Magnuson-Stevens Fishery Conservation and Management Act (MSA) established procedures designed to identify, conserve, and enhance Essential Fish Habitat (EFH) for species regulated under a Federal Fisheries Management Plan (FMP) such as Pacific salmon. MSA was first enacted in 1976, and amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267). The Magnuson-Stevens Fishery Conservation and Management Reauthorization Act of 2006 was signed January 12, 2007 (NMFS 2007).

EFH is the aquatic habitat necessary to fish for spawning, breeding, feeding, or growth to maturity to support the managed species population, a long-term sustainable fishery, and the species contribution to a healthy ecosystem (Federal Register 2002). EFH's designated by the Pacific Fishery Management Council within the Bay-Delta area cover species managed under three different fishery management plans (FMPs): (1) the Pacific Groundfish FMP; (2) the Coastal Pelagic Species FMP; and, (3) the Pacific Salmon FMP. The Bay-Delta provides habitat for Sacramento River winter-run Chinook salmon (*Oncorhynchus tshawytscha*), Central Valley spring-run Chinook salmon (*O. tshawytscha*), Central Valley fall-/late fall-run Chinook salmon (*O. tshawytscha*), northern anchovy (*Engraulis mordax*) and starry flounder (*Platichthys stellatus*), which are covered under the EFH provisions of the MSA. Federal action agencies must consult with NMFS on any activity which they fund, permit, or carry out that may adversely affect EFH.

The vision for EFH is to maintain the quality of habitat available through actions directed towards improving streamflows, coarse sediment supply, water quality, access and passage, stream meander, natural floodplain and processes and maintaining and restoring riparian and riverine aquatic habitats. ERP Goal 4 is to protect, restore, or enhance habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics. ERP and EFH have a similar vision for habitat restoration and ERP will continue to support projects that target conservation priorities under Goal 4 (see Section 5).

Tidal Perennial Aquatic. Tidal perennial aquatic habitats, particularly areas less than 9 feet deep at mean high tide, are important habitat use areas for many species of fish and wildlife in the Delta. The substantial loss of historic shallow-water areas, primarily as a result of reclamation of tidally influenced habitat and channel dredging, has reduced the available habitat area for associated fish and wildlife. Loss of shallow-water areas has also caused a reduction in primary and secondary productivity which contributed to changing the historic foodweb of the Delta.

Tidal aquatic habitats in the Delta include mainstem and low order channel habitats. Tidal mainstem channel habitats include rivers, major creeks, or major sloughs forming Delta islands where water is understood to have ebbed and flowed in the channel at times of low river flow. These channels are of high order with large contributing watersheds or are subtidal (i.e., beds below mean lower low water, MLLW) sloughs that delineate the Delta islands.

Tidal low order channels comprise the sinuous channel networks of the Delta's tidal marshes that usually taper and branch toward the upland edge or drainage divide within a Delta island. They are blind tidal channels (i.e., dead-end channels terminating within wetlands) where tides ebbed and flowed within the channel at times of low river flow. Tidal low order channels include both subtidal (beds below MLLW) and intertidal (beds exposed at low tide or beds only wetted at spring tides). Most tidal low order channels are limited to tidal wetlands. Exceptions include the headward reaches of tidal channels that intersect non-tidal uplands.

Dead-end sloughs provide warmer, highly productive habitat for seasonal spawning, rearing, and foraging of important aquatic organisms, as well as important carbon production for other Bay-Delta habitats. Several smaller branches of tidal slough networks have been severed from the main slough channel by levees. For waterfowl and wildlife, dead-end sloughs have associated marsh and riparian corridors important for breeding, feeding, resting, and roosting.

Open-ended sloughs provide unique, generally low-velocity habitats and important migratory pathways for many species and important habitat for wildlife and waterfowl along the riparian corridors of the sloughs. Levee construction and channel dredging over many years has converted the gradual sideslopes supporting marsh and tideflat habitat along sloughs to steep-sided, high-velocity channels with narrow or nonexistent shoreline habitat.

Intertidal Areas. Tidal marshes across North America have been shown to play a critical role for native fish by providing improved foraging opportunities, increased growth, and refuge from predators (Boesch and Turner 1984, Baltz et al. 1993, Kneib 1997, Madon et al. 2001). The tidal marshes of the Delta have received relatively little study; however, research conducted in the San Francisco Estuary and elsewhere along the Pacific coast has shown tidal marshes provide benefits to native fish, especially salmonids (Simenstad et al. 1982, West and Zedler 2000, Bottom et al. 2005a, Maier and Simenstad 2009).

Intertidal areas in the Delta are best characterized as lands between one and seven feet above sea level, depending on location (Figure 4). All lands in the intertidal range are assumed to have the ability to support some tidal marsh habitats (either brackish or freshwater) with associated mudflats, sloughs, channels, and other open water features. Some areas are capable of supporting large areas of contiguous habitat, and others may support only small patches (e.g., mid-channel islands and shoals). Properly functioning tidal marsh habitats have subtidal open water channels with systems of dendritic and progressively lower-order intertidal channels that dissect the marsh plain. These diverse habitats provide structure and processes that benefit both aquatic and terrestrial species.

The rationales for protection and enhancement of fresh and brackish tidal marsh areas are contained in the ERPP, and the reader is encouraged to refer to these volumes for more information (CALFED 2000a). For the purposes of this Conservation Strategy, the discussion on restoring habitats in intertidal areas will focus on what has been learned about the importance of these areas since 2000, particularly as the strategy relates to various species' use of tidal marsh areas and the role of these areas in enhancing the aquatic food web.

Studies of species' use of tidal marsh habitat in the Delta are limited, but ERP and other programs have conducted several studies since the signing of the ROD that continue to augment knowledge regarding the role of intertidal habitats for desirable aquatic species. The largest effort to study tidal marsh habitat in the Delta and its benefits to native fish was a series of projects known as the BREACH studies, which investigated geomorphology, sedimentation, and vegetation at four reference sites and six restored tidal marsh sites in the Delta. Of the one reference and three restored sites sampled for fish and invertebrates, relative density of both native and introduced fish species was higher at the reference site (Simenstad et al. 2000). Although all of the sites were dominated by introduced fish, the abundance of native fish was highest in winter and spring (Grimaldo et al. 2004). In stomach content analyses, all life stages of chironomids (midges) were shown to be a very important food source for fish, both adjacent to tidal marsh habitats and in open water areas. Chironomid association with marsh vegetation indicates the importance of this habitat to the aquatic food web. Overall abundance of fish larvae was highest in marsh edge habitat when compared to shallow open water and river channels (Grimaldo et al. 2004).

An example of an ongoing study of species use of tidal marsh within intertidal land elevations is the ongoing monitoring associated with restoration of Liberty Island, a 5,209-acre island in the northern Delta that breached naturally in 1995. The Liberty Island project provides a good example of passive restoration of various habitat types, including some deeper, open water subtidal areas at the southern end and freshwater emergent tidal marsh and sloughs with riparian habitat at the higher elevations at the northern end. Liberty Island's sloughs are populated with otters, beavers, muskrats, and numerous species of ducks and geese. Native fish species using the area include Chinook salmon, splittail, longfin and delta smelt, tule perch, Sacramento pike minnow, and starry flounder. In some areas, native species account for up to 21 percent of the fish collected; for reference, native species only account for approximately 2 to 10 percent elsewhere (Malamud-Roam et al. 2004). Ongoing monitoring at Liberty Island for almost eight years is showing that fish species assemblages at this restored area increasingly resemble assemblages at reference marsh sites. ERP hopes to build upon the success of this restoration by increasing its size and developing a dendritic channel system on its interior (DFG 2010e).

In many estuaries of the Pacific Northwest, including the Columbia and Fraser River estuaries, Chinook salmon fry usually occupy shallow, near shore habitats including tidal marsh, where they feed and grow and adapt to salt water (Healey 1982, Levy and Northcote 1982, Simenstad et al. 1982, McLain and Castillo 2010). They often move far up into tidal wetlands on high tides, and may return to the same channels on several tidal cycles (Levy and Northcote 1982). In estuaries throughout Washington, subyearlings and fry occur mainly in marshes when these habitats are available (Simenstad et al. 1982). In fact, Healey (1982) identified freshwater tidal marshes as the most important habitat to juvenile salmon in the Pacific Northwest.

Tidal marsh restoration has been shown to result in recovery of life history diversity in the Salmon River estuary of Oregon. Tidal marsh habitat in this estuary had largely been lost due to diking by the early 1960s (Gray et al. 2002). In surveys conducted in the mid-1970s, Chinook salmon juveniles were found to rear in the estuary only to a limited extent during the spring and early summer months. Three sites in the estuary were restored to tidal action between 1978 and 1996 and by the early 2000s juvenile salmon were making extensive use of restored marsh habitats for rearing, with estuarine resident times up to several months. Tidal marsh restoration expanded life history variation in the salmon population; the amount of time spent rearing in the estuary was variable and juveniles moved into the ocean over a broad range of time and at a broad range of sizes (Bottom et al. 2005b). Chinook salmon show remarkable phenotypic plasticity in their ability to adapt to new locations and form multiple life history types from a single introduction of fish (Williams 2006); with restoration of tidal marsh in the Delta, Chinook salmon in the Sacramento and San Joaquin rivers may be able to regain appropriately varied life history types over time.

A number of additional studies are demonstrating that regardless of species actual use of tidal marsh areas, these habitats could be extremely important for their possible role in augmenting the Delta's aquatic food web, particularly in the saline portion of the estuary.

- Tagging and stomach content studies show that Chinook salmon fry may use intertidal habitat. According to Williams (2006), tagged hatchery fry remain in the Delta up to 64 days and tend to occupy shallow habitats, including tidal marsh. Stomach contents of salmon rearing in the Delta are dominated by chironomids and amphipods, suggesting that juvenile salmon are associated with marsh food production. Juvenile salmon in the Delta also undergo substantial growth (Kjelson et al. 1982, Williams 2006). More recently, in the Columbia River estuary, emergent tidal marsh has been shown to support the greatest abundance of insects and highest stomach fullness scores for juvenile salmon, with chironomids again being the dominant prey type (Lott 2004).

- In a study of carbon types and bioavailability, tidal marsh sloughs in Suisun Bay had the highest levels of dissolved, particulate, and phytoplankton-derived carbon (Sobczak et al. 2002). Chlorophyll *a* concentration, used as a measure of standing crop of phytoplankton, was highest in tidal sloughs and supports the greatest zooplankton growth rate (Mueller-Solger et al. 2002) when compared to other habitat types, such as floodplains and river channels. High levels of primary production (measured by Chlorophyll *a*) as seen in several regions in the interior of Suisun

Marsh are likely due to high residence time of water, nutrient availability, and absence of non-native clams (DFG 2010e).

- Modeling (Jassby et al. 1993, Cloern 2007) and empirical studies (Lopez et al. 2006) show that productivity from high-producing areas, such as marsh sloughs, is exported to other connected habitats. Phytoplankton biomass location is only weakly correlated with phytoplankton growth rates across several aquatic habitats. Therefore other processes, including mixing and transport, are important in determining phytoplankton distribution in the Delta. The data shows that Suisun Marsh plays a significant role in estuarine productivity by providing an abundant source of primary production and pelagic invertebrates, both of which are significantly depleted in bay and river channel areas (DFG 2010e).

Tidal marsh may also help improve the pelagic food web by reducing the concentration of ammonium in the water. Ammonium has been shown to inhibit phytoplankton blooms in Suisun Bay by inhibiting the uptake of nitrate by diatoms (Wilkerson et al. 2006, Dugdale et al. 2007). In a nutrient-rich estuary in Belgium, tidal freshwater marsh was shown to transform or retain up to 40 percent of ammonium entering the marsh during a single flood tide (Gribsholt et al. 2005). Nitrification (the conversion of ammonium to nitrate) accounted for a large portion of the transformation (30 percent). Nitrification rate in the marsh system was measured at 4 to 9 times that which occurs in the adjacent water column (Gribsholt et al. 2005). Increased tidal marsh habitat may, therefore, improve the base of the aquatic food web in the Delta by increasing primary production within the marshes, and by increasing the ratio of nitrate to ammonia in the estuary.

At the outset of ERP, restoration of intertidal and shallow subtidal areas was a very high priority, and based on what has been learned since 2000, continues to be a very high priority for the Delta. However, the extensive spread of non-native SAV in intertidal and shallow subtidal areas renders them less suitable for native fish (Nobriga et al. 2005, Brown and Michniuk 2007, Nobriga and Feyrer 2007). Brown and Michniuk (2007) reported a long-term decline in native fish abundance relative to non-native fish. This decline in native fish abundance occurred coincident with the range expansion of non-native SAV (principally *Egeria densa*) and non-native black bass (centrarchids), both of which are discussed further in the Stressors section. Predation by largemouth bass is one mechanism hypothesized to result in low native fish abundance where SAV cover is high (Nobriga et al. 2005). Largemouth bass have a higher per-capita predatory influence than all other piscivores in SAV-dominated intertidal zones (Nobriga and Feyrer 2007). Restoration of Delta intertidal habitats must, therefore, be designed and managed to discourage non-native SAV, or native fish may not benefit from them (Grimaldo et al. 2004, Nobriga and Feyrer 2007).

In summary, restoration of tidal marsh areas in the Delta remain a very high priority for ERP; however, several cautions must be kept in mind. Appropriate freshwater flow, channel geometry and water quality conditions are necessary to provide a more productive and connected aquatic food web. A major concern is that restored tidal marsh could be colonized by non-native species (e.g., overbite clams and SAV), which would in turn limit the benefits to native species. Another potential constraint facing the restoration of intertidal habitats is the methylation of mercury in sediments. Therefore, restoration of tidal marsh within intertidal land elevations should be designed as small-scale studies, and should be rigorously monitored to establish relationships between this habitat and species population abundance. As this information continues to be collected and synthesized, the risk and uncertainty associated with restoring this habitat are expected to decrease.

Fluvial. Fluvial habitats include rivers or major creeks with no influence of tides. They are important habitat-use areas for many species of fish and wildlife in the Delta, particularly in areas less than 6 feet deep. The substantial loss or degradation of fluvial habitats, primarily as a result of reclamation of wetlands and alteration of streamflows, has reduced the available habitat area for associated fish and wildlife.

In the Delta, fluvial habitats include mainstem channels of rivers and major streams such as Putah and Cache creeks. These channels are of high order with large contributing watersheds. Fluvial low order channels include distributaries, overflow channels, side channels, swales and other minor channels within the upland Delta edge, channels associated with crevasse splays or other overflow channels dissecting natural levees, and channels within floodplain non-tidal marshes. Channels of this classification are commonly intermittent and dominated by fluvial processes. Such channels often dissipate across alluvial fans or natural levees toward lower-lying wetlands.

Fluvial channels dissecting the natural levees of the tidally-influenced Sacramento River generally only flow at high river stages, meaning that their channel beds are likely above the elevations of high tides during low river stages. The numerous side channels and former channel meanders lacing the wetlands of the upper reaches of the San Joaquin distributaries, many of which carry water only during flood season, are also classified as fluvial low order channels. These channels do not carry tidal flows, despite in many cases being surrounded by tidal rivers (e.g., present day Stewart Tract).

Floodplain. A natural floodplain, in the absence of levees, is an important component of rivers and estuaries that allows many essential ecological functions to occur. Healthy floodplains are morphologically complex. They include backwaters, wetlands, sloughs, and distributaries that carry and store floodwater. Floodplain areas can constitute islands of biodiversity within semi-arid landscapes, especially during dry seasons and extended droughts. The term *floodplain* as used here means the generally flat area adjoining rivers and sloughs that are inundated every 1.5 to 2 years when flows exceed the capacity of the channel (bank full discharge). Peak flows in winter and spring that occur every 1.5 to 2 years are considered by river geomorphologists to be the “dominant discharge” that contributes the most to defining the shape and size of the channel and the distribution of sediment, bar, and bed materials.

Floodplain areas have the potential to support highly productive habitats, as they represent a heterogeneous mosaic of habitats including riparian habitat, freshwater tidal marsh, seasonal wetlands, perennial aquatic, and perennial grassland habitats, in addition to agricultural lands. During inundation floodplains are used by numerous native fish for spawning and early growth (Moyle 2002). There has been extensive research on the Yolo Bypass and lower Cosumnes River, in addition to some research in the Sutter Bypass, indicating that native resident and migratory fish show a positive physiological response (i.e., enhanced growth and fitness) when they have access to floodplain habitats (Moyle et al. 2004, Ribeiro et al. 2004, Moyle et al. 2007), which likely benefits them as they complete subsequent stages of their respective life cycles. Inundated floodplain areas provide important spawning and rearing habitat for splittail and rearing habitat for juvenile Chinook salmon (Sommer et al. 2001a, Sommer et al. 2002, Moyle et al. 2007). Splittail need about 30 consecutive days of floodplain inundation to produce good survival through the larval stage and survival improves with longer durations (Moyle et al. 2004). Without access to adequate floodplain spawning habitat, splittail reproduction declines drastically as seen during the late 1980s and early-1990s.

Managing the frequency and duration of floodplain inundation during the winter and spring, followed by complete drainage by the end of the flooding season, could favor native fish over non-natives (Moyle et al. 2007, Grimaldo et al. 2004). Frequency, timing, and duration of inundation are important factors that influence ecological benefits of floodplains. To favor splittail recruitment and to benefit salmon fry and smolt growth during above normal and wet years, once 10 days of floodplain inundation have been achieved in late November or later, then uninterrupted inundation should be maintained for at least 30 days with drainage to occur by the end of April occasionally extending into mid-May in the Yolo Bypass and at suitable locations in the Sacramento River or the San Joaquin River (DFG 2010b).

Studies on the Cosumnes and Sacramento Rivers indicate that dynamic processes are needed to support complex dynamic riparian habitats and upland systems which form the floodplain habitat (Moyle et al. 2007). Native plants and animals have adapted to the random brief floodplain events that are characteristic of California's hydrology. Riparian habitats would be a component of these future restoration actions. Extant riparian habitats exist along levees and at the higher elevations in intertidal habitats, and in floodplain habitats – usually on fluvial soils or where levees are created with a mineral soil. The voluntary recruitment of this habitat type on Prospect Island and the higher elevation areas of Liberty Island and Little Holland Tract underscore the proclivity of natural restoration when proper soil and water conditions and elevations occur.

Research on the Cosumnes River also shows the many ecosystem benefits that floodplains provide. The Cosumnes River is the only remaining unregulated river on the western slope of the Sierra Nevada. The Cosumnes River Preserve comprises 46,000 acres. The free-flowing nature of the river allows frequent and regular winter and spring overbank flooding that fosters the growth of native vegetation and the wildlife dependent on those habitats. In addition to the value of floodplain habitat to the Delta's native species, floodplains are believed to enhance the estuarine food web, as they support high levels of primary and secondary productivity by increasing residence time and nutrient inputs into the Delta (Sommer et al. 2004). Ahearn et al. (2006) found that floodplains that are wetted and dried in pulses can act as a productivity pump for the lower estuary. With this type of management, the floodplain exports large amounts of Chlorophyll *a* to the river. Inundated floodplain habitat on the Cosumnes River Preserve has been shown to provide many benefits to native fish (Swenson et al. 2003, Ribeiro et al. 2004, Grosholz and Gallo 2006, Moyle et al. 2007).

Because floodplain areas are inundated only seasonally, many other habitat types that occur in upland areas can be accommodated on floodplains when high winter and early spring flows are not present. The DWR's Flood Protection Corridor Program provides grant funding to local agencies and nonprofit organizations for nonstructural flood management projects that include wildlife habitat enhancement and/or agricultural land preservation, and acquisition of flood easements. Such easements provide a way to bring floodplain benefits to species seasonally, while also accommodating agricultural production in summer, fall, and early winter. Delta crops such as rice, grains, corn and alfalfa provide food for waterfowl and other terrestrial species and in some cases may serve as surrogate habitat in the absence of historical habitat. From Highway 99 west to the Cosumnes River Preserve is a good example of an area that provides a wildlife-friendly agriculture mix. It is the largest conservation easement acquisition funded by ERP during Stage 1. The ERP also provided funding for planning activities or property acquisitions and restoration of wildlife friendly agriculture in the Yolo Bypass, along the Cosumnes River, and along the San Joaquin River near Mossdale Crossing.

Although the benefits of floodplains have been demonstrated, there are several cautions related to restoring seasonal floodplains:

- Restoration must incorporate as much natural connection with the river as possible to reduce potential stranding of native fish. Large-scale flooding events also help reduce stranding by creating channels on the landscape which allow for natural drainage, and multiple pulse flows help ensure fish receive the migratory cues they need. Isolated deep drainage canals or other unnatural scour holes deeper than a couple of feet should be reduced. Such areas remain too cool during drainage and do not provide the emigration cues needed for most fishes.

- The periodic wetting and drying of floodplains make these areas especially prone to methylmercury production and transport. Within the context of the Delta Total Maximum Daily Load (TMDL) for methylmercury that is currently being developed, floodplain restoration activities should include the investigation and implementation of Best Management Practices (BMPs) to control methylmercury production and/or transport.

Nontidal Perennial Aquatic. Nontidal perennial aquatic habitats occupy topographic depressions that are perennially inundated and that lack abundant emergent marsh vascular plants. Several deep open water areas exist in the Delta as a result of the flooding of islands such as Franks Tract and Mildred Island (also called pelagic habitat).

These flooded island areas have been shown to produce hydrodynamic conditions unfavorable to some native fish species.

Perennial ponds and lakes of the historical Delta generally occupied backwater areas (against natural levees or the upland edge) within the wetlands of low-elevation lands lying parallel to the rivers, or flood basins. These areas probably received very little inorganic sediment. In some locations, large woody debris that caused waters to be impounded may have been important in the formation and maintenance of these features. Those nontidal perennial aquatic habitats within the wetland complex are generally fed by surface water, with groundwater a component particularly in the summer months. Those within the upland ecotone, or zone of transition between perennial wetland and marginal habitats, may be fed by a combination of surface water, groundwater, and direct precipitation (Whipple 2012).

Upland Areas. Connectivity of existing habitat to higher elevation areas will be critical for Delta habitats and species with rising sea level, and regional climate change. As the sea level rises, existing intertidal habitat will become subtidal, and adjacent uplands will become intertidal. Additionally, adjacent higher elevation habitat will be critical for wildlife to escape flooding. Changes in regional climate are expected to result in precipitation patterns of more rain and less snow, shifting tributary peak runoff from spring to winter, making extreme winter runoff events more frequent and intense, and bringing about longer dry periods in summer. In light of these expected changes, and ongoing conversion of open space lands to urban uses, some of these higher elevation areas will be expected to accommodate additional flood flows in new or expanded floodplain areas.

Upland areas in the Delta are best characterized as lands well above current sea level (i.e., greater than five feet in elevation above Mean Sea Level (MSL), depending on location). Aquatic habitats in this category include seasonally-inundated floodplain, seasonal wetlands (including vernal pools), and ponds, while terrestrial habitats in this category include riparian areas, perennial grasslands, and inland dune scrub, as well as agricultural lands. Protecting and creating a mosaic of different upland habitat types that are well distributed, and connected to other natural communities is important for maintaining genetic diversity of the numerous species which use these areas for all or part of their life cycles. The aquatic and terrestrial habitat types that comprise upland areas often co-occur (e.g., agricultural lands that are seasonally inundated to benefit waterfowl, and perennial grasslands that support vernal pools). Thus, this habitat category highlights the importance of preserving and enhancing a diversity of habitats in support of numerous species and ecological processes, as well as allowing the system to respond to drivers of change such as sea level rise.

The rationales for protection and enhancement of seasonal wetlands, vernal pools, riparian areas, perennial grasslands, and inland dune scrub are contained in the ERPP, and the reader is encouraged to refer to these volumes for more information (CALFED 2000b). For the purposes of this Conservation Strategy, the discussion on restoring upland habitats in the Delta will be focused on seasonally-inundated floodplains and protection and management of agricultural and open space lands for wildlife-compatible uses.

With increasing sea level, and regional climate change, uplands adjacent to Delta tidal fresh and brackish wetlands will be important for future landward migration of these wetlands. In light of these expected changes, protection of uplands from ongoing conversion to urban uses should be a high priority to allow adaptation to climate change and maintain sustainable natural aquatic communities into the future.

Much has been learned since 2000 about creating habitats in upland areas, particularly with respect to seasonally-inundated floodplains and their importance to many of the Delta's aquatic species. As knowledge has increased, the risk and uncertainty associated with restoring this habitat is decreasing. Thus, restoration of seasonally-inundated floodplains is a very high priority for the Delta in the near term.

Agricultural Lands. It is important to note that a significant portion of the land within the Delta is dedicated to agricultural production, some of which is considered suitable for habitat restoration. Some U.S. Department of Agriculture programs exist that provide financial incentives for landowners to manage natural areas on their properties, including but not limited to the Wildlife Habitat Incentives Program, the Environmental Quality Incentives Program, and the Conservation Reserve Program. While largely successful in other States, additional funding for implementation of these programs in California should be requested to make participation more attractive to landowners who face higher capital and production costs. ERP will continue to fund projects on agricultural lands which benefit wildlife and help ensure that agricultural properties are conserved.

Upland Transitional Corridor. The establishment of a corridor of protected agricultural and natural lands is needed to protect valuable habitats and to facilitate the movement of wildlife. An example is the area between the Delta's Cache Slough area and the Denverton Slough in Suisun Marsh. These areas currently contain a mosaic of perennial grasslands and vernal pool areas, and have been identified by local planners as having great potential for ecological benefits from restoration.

Subsided Uplands. Subsided upland areas in the Delta are best characterized as land well below current sea level (below approximately six feet in elevation below MSL). Terrestrial areas in this category include mainly agricultural lands, some of which are not in active agricultural production. Central Valley Joint Venture recognizes that agricultural easements to maintain waterfowl food supplies and buffer existing wetlands from urban development may become increasingly important in basins where large increases in human populations are predicted (CVJV 2006). In addition, ongoing rice cultivation may help minimize subsidence. Subsidence reversal, carbon sequestration, and wildlife-friendly agricultural projects are appropriate on these deep islands in the near term, as they are expected to provide benefits to the local economy, wildlife, and waterfowl while protecting lands from uses that may be unsustainable over the longer term.

The rationales for protection and enhancement of seasonal wetlands and wildlife-friendly agriculture are contained in the ERPP, and the reader is encouraged to refer to these volumes for more information (CALFED 2000b). For the purposes of this document, the discussion on restoring habitats on subsided lands will be focused on subsidence reversal and carbon sequestration.

With increasing sea level and regional climate change, the existing configuration of Delta levees and deeply subsided islands are not expected to remain intact over the long term. A forecast rise in sea level ranging from 30 cm to 45 cm by 2050 (Cayan et al. 2009), is expected to increase pressure on the Delta's levee system. Changes in regional climate and the shift of tributary peak runoff from spring to winter are expected to make extreme winter runoff events more frequent and intense, further compounding pressure on Delta levees seasonally. In light of these expected changes, in addition to human-induced impacts (e.g., increased runoff from continued conversion of open space lands to urban uses), there is a considerably higher likelihood of Delta levee failure and subsequent island flooding in the future. ERP implementation must therefore work to develop measures to reduce stressors as well as adapt to these expected pressures. This may include planning ways to optimize newly-flooded deep islands for the aquatic species that may utilize them in the future.

Dune Scrub Habitat. Two ERP grants have been used to fund surveys to locate potential habitat restoration sites capable of supporting Antioch dunes evening primrose, Contra Costa wallflower, and Lange's metalmark butterfly. Potential areas were located and are being assessed for enhancement, but no enhancement has been funded nor have funds for annual monitoring and reporting been identified. Continued evaluation and enhancement of dune scrub habitat is needed during Stage 2 implementation.

Seasonal Wetlands. Seasonal wetlands include vernal pools, wet meadows or pastures, and other seasonally wetted habitats such as managed duck clubs in the Delta floodplain. Most of this habitat is located on leveed lands or in floodplain bypasses such as the Yolo Bypass. Such habitats were once very abundant during the winter rainy season or after seasonal flooding of the Delta. With reclamation, flooding occurs primarily from accumulation of rainwater behind levees, from directed overflow of flood waters to bypasses, or from flooding leveed lands (e.g., managed wetlands). Seasonal wetlands are important habitat to many species of fish, waterfowl, shorebirds, and wildlife.

Increased seasonal flooding of leveed lands and flood bypasses will provide important habitats for shorebirds, waterfowl, raptors, native plants and wildlife and for the spawning, rearing, and migration of native fish species. While the extent remains uncertain, flooding and draining of seasonal wetlands also contributes to the aquatic and terrestrial foodwebs of the Delta and Bay.

Wetland habitats in the Central Valley could be particularly impacted by climate change. Changes in rates of evaporation, precipitation, snow melt, stream flow, sea level rise and various other processes will likely reduce predictability of water availability for wetland management and rice and corn agriculture in California. These impacts could be exacerbated by rapid landscape changes associated with human population increases and urbanization, invasive plant species, and reductions in deliverable water quality and quantity.

III. Stressors

ERP identified several stressors that negatively affect the Delta's ecosystem health as measured by the state of its native species, ecological processes, and habitats, and in 2010 CDFW identified several stressors impacting Delta related organisms that were reported to the Fish and Game Commission (DFG 2010d). The focus in this element of the Conservation Strategy for the Delta is on stressors including loss of habitat (ERP Goal 4), non-native invasive species (ERP Goal 5), water and sediment quality (ERP Goal 6), water diversions, and barriers to connectivity of habitats (such as dams and levees).

Loss of Habitat. The Bay Institute has estimated that intertidal wetlands in the Delta have been diked and leveed so extensively that approximately 95 percent of the 141,640 hectares (ha)(350,000 acres(ac)) of tidal wetlands that existed in 1850 are gone (The Bay Institute 1998). Diking, dredging, filling of wetlands, and reduction of freshwater flows through more than half of the rivers, distributary sloughs, and the estuary for irrigated agriculture and urban use have widely reduced fish habitat and resulted in extensive fish losses (Moyle et al. 1995).

One hundred and fifty years ago, detrital food webs were supported by vast amounts of organic carbon from the rich intertidal wetlands. These detrital food webs probably dominated community energetics within the upper estuary, providing widely distributed high-quality habitat for aquatic estuarine species both upstream and downstream of Suisun Bay. With suitable habitat and food plentiful throughout the area, fishes could move about freely to rear, spawn, or adjust to salinity variations. The modern focus on the position of the mixing zone in Suisun Bay in part reflects the loss of this formerly more widely distributed habitat (Whipple 2012).

Changes in Flows. Human activities have fundamentally, and irreversibly, altered hydrologic processes in the Bay-Delta ecosystem. For example, changes in land use have affected how and when water drains from the land into stream channels; water diversions have: changed the amount of water flowing through tributaries and the Delta; and dam development has profoundly altered the timing, frequency, and magnitude of flows. Extensive water development has generally affected the flow regime by reducing the seasonal and inter-annual variability of flows, as reservoirs capture and store stormwater and snowmelt runoff for later release as water supply. Such changes to the flow regime stress native habitats and species that evolved in the context of a variable flow regime. Restoring variability to the flow regime will be an important component of restoring ecological function and supporting native habitats and species in the Bay-Delta ecosystem.

Currently, salinity in the Delta and Suisun Bay is controlled during much of the year by reservoir releases designed to protect agriculture, urban water supplies, and aquatic organisms (SWRCB 1995). Statistically significant relationships have been demonstrated between the position of the 2 ppt isohaline (X2) and the abundance of estuarine species, including striped bass, *Neomysis*, *Crangon*, starry flounder, and the base of the food chain, phytoplankton-derived particulate organic carbon (Jassby et al. 1995). Some of these relationships appear to have weakened somewhat and shifted downward since the introduction of *Potamocorbula* in 1986 (Kimmerer 1998). Aquatic organisms are now protected during February through June by requiring minimum flows at Collinsville (confluence of the Sacramento and San Joaquin rivers), and by controlling the number of days that X2 is present at Chipps Island and Port Chicago (Whipple 2012).

Non-Native Invasive Species

Non-Native Invasive Species. Immense ecological changes have occurred throughout the Bay-Delta ecosystem as a result of introduced non-native invasive species (NIS) (SFEI 2003). NIS species can affect natural ecosystem processes and functioning by altering food webs and habitats, competing with native species for resources, and directly prey upon native species. NIS represents one of the biggest impediments to restoring habitats and populations of native species (CALFED 2000a). NIS have been introduced into the Delta over time via several mechanisms, the most common being discharge of ships' ballast water in ports. NIS are also transported from one place to another via watercraft, fishing gear, live bait, intentionally (either legally or illegally) introduced for recreational or other purposes (e.g., centrarchids), or released from aquariums into the environment. In 2006, the SWRCB listed the Delta, upper San Joaquin River, and Cosumnes River on its 303(d) list as impaired for exotic species and is scheduled to develop a TMDL to address the exotic species listings for these waterways by 2019 (SWRCB 2007).

The ERP has funded many projects since 2000 to educate the public about, and control the threat of NIS. Such projects included a study of the feasibility of ships exchanging their ballast water out in the ocean rather than destination ports. Other ERP projects provided outreach geared toward educating recreational boaters and anglers, as well as individuals involved in the aquarium trade, on the threats posed by NIS.

As part of the Bay-Delta (formerly CALFED) NIS Program, a Strategic Plan and an Implementation Plan were developed, and the Non-Native Invasive Species Advisory Council (NISAC) was established. The NISAC no longer meets; however the USFWS, CDFW, and other stakeholders continue to coordinate and implement activities and projects that address NIS issues in the Bay-Delta area of concern. The USFWS is currently promoting an invasive species prevention approach known as Hazard Analysis and Critical Control Point Planning (HACCP). HACCP is a risk management planning tool that originated with the food industry, but has been modified to include natural resource management. The HACCP features five integrated steps that can reduce the risk of spreading invasive species and other non-targets via human-based pathways. HACCP examines activities to determine if and when particular invasive species might be unintentionally moved. Where this potential exists, the tool helps to identify the most effective opportunities during an activity to reduce that risk and the specific control measures that are needed. Safeguards are included through the use of prescribed ranges, limits, or criteria (previously called a control limit) and corrective actions that ensure that control measures are operating as intended.

As a separate effort, CDFW issued its California Aquatic Invasive Species Management Plan (CAISMP) in January 2008. CAISMP's focus is on coordinating the efforts of State agencies to minimize the harmful ecological, economic, and human health impacts from aquatic invasive species. CAISMP provides a common platform of background information from which State agencies and other entities can work together to address the problem of aquatic invasive species, and identifies major objectives and associated actions needed to minimize these impacts in California. Depending on the species and the level of invasion, there are different management responses that could be pursued. The CAISMP includes examples of management responses to specific invasive species in the Delta. The NIS of highest management concern in the Delta includes:

Non-Native Fishes. Non-native fish species can have a large negative impact on native fish in the Delta through predation and competition (Nobriga and Feyrer 2007, Brown and Michniuk 2007). Native Delta fishes evolved for thousands of years with only the predatory pressure of native species. Although native Delta fishes have co-existed with non-native predators for over 100 years, it is uncertain whether the native populations, which are now mostly depleted, can recover in the presence of large populations of non-native predators (Moyle 2002). Given the recent population crashes of Delta native fishes, it remains important to examine the effects of predation by non-native species, most notably striped bass. Striped bass are widely recognized, from fish academics (Moyle 2002) to sport fishing guides, as a predator of salmonid smolts and other native fish. It is worth noting that striped bass numbers have also recently declined resulting in its addition to the POD species list.

The predation pressure exerted on salmon and steelhead by largemouth bass and smallmouth bass in the Central Valley is less well understood compared to striped bass, but is potentially another important source of predation. Largemouth bass are abundant and widely distributed throughout the Delta (Brown and Michniuk 2007) and smallmouth bass are abundant in some Delta habitats and in the lower sections of upstream tributaries. Both species are aggressive predators consuming virtually any prey smaller than the size of their gape, including fish, rats, mice, ducklings, frogs, snakes, and salamanders (Sanderson et al. 2009). Largemouth bass are known to feed on Chinook salmon in the Delta and are likely to have a substantial impact on the shallow-water fish community (Nobriga and Feyrer 2007). The abundance and distribution of smallmouth bass in the Central Valley may also be a cause for concern for the survival of salmon and steelhead. Smallmouth bass are well documented to be a predator of salmon in the northwest (Fritts and Pearsons 2006, 2008; Harvey and Kareiva 2005; Naughton et al. 2004), and in some rivers, such as the Yakima River, they are considered to be the dominant predator of salmonids (Fritts and Pearsons 2006). However, some studies suggest that smallmouth bass do not have a large impact on salmon (Harvey and Kareiva 2004; Naughton et al. 2004; Tabor et al. 2007). In the Central Valley, much more information is needed regarding the impact of largemouth and smallmouth bass predation on salmonids in order to assess the magnitude of the threat and help determine whether management actions should be pursued.

In addition to striped bass, largemouth bass, and smallmouth bass, other non-native fish that are now common to the Delta include spotted bass, bluegill, warmouth, redear sunfish, green sunfish, white crappie, black crappie, and silversides.

Overbite Clam. The overbite clam (*Potamocorbula amurensis)* was first observed in 1986 and has since become extremely abundant in Suisun Bay and the western Delta (Carlton et al. 1990). This species is well adapted to the brackish areas of the estuary and is largely responsible for the reduction of phytoplankton and some zooplankton in the Bay-Delta region (Kimmerer 2006). This loss of primary and secondary production has drastically altered the food web and is a contributing cause of the POD (Sommer et al. 2007). Overbite clam have been shown to strongly bioaccumulate selenium (Linville et al. 2002), which could have reproductive implications for fish (Stewart et al. 2004) and diving ducks that feed on overbite clam.

Asian Clam. The Asian clam (*Corbicula fluminea)*, introduced from Asia, was first described in the Delta in 1946 (USGS 2001). This clam does not tolerate saline water. It is now very abundant in freshwater portions of the Delta and in the mainstem of rivers entering the Delta. Ecologically, this species can alter benthic substrates and compete with native freshwater mussels for food and space (Claudi and Leach 2000).

Because the overbite clam and Asian clam have become so well-established in the estuary, there is currently no known environmentally acceptable way to treat or remove these invertebrates (DFG 2008). The only apparent management action at this time is to determine whether the manipulation of environmental variables, such as salinity, can be used to seasonally control their distribution in the estuary. There is no consensus among scientists that manipulation of salinity would do much to affect the distribution of these clams or diminish their impacts on the estuarine food web (Healey et al. 2008).

Zebra Mussel and Quagga Mussel. Neither the zebra mussel (*Dreissena polymorpha)* nor quagga mussel (*Dreissena bugensis)* have been observed in the Delta, but given suitable environmental conditions these species have proven to be highly invasive. Establishment of dreissenid mussels is limited by salinity greater than 10 ppt (Mackie and Claudi 2010). In addition to similar threats to the ecosystem posed by the overbite clam and Asian clam, dreissenid mussels colonize hard and soft surfaces, often in high densities (greater than 30,000 individuals per square meter), and can impede the flow of water through conveyances. One of the most predictable outcomes of a dreissenid invasion, and a significant abiotic effect, is enhanced water clarity linked to a greatly diminished phytoplankton biomass. For example, rotifer abundance in western Lake Erie declined by 74 percent between 1988 and 1993, the same time that an enormous zebra mussel population became established in that area (Claudi and Leach 2000).

A State and Federal interagency coordination team was established to coordinate management responses to the threat of further quagga spread in California. Three subcommittees were established: Outreach and Education, Monitoring, and Sampling/Laboratory Protocols. The Quagga Mussel Scientific Advisory Panel was convened in April 2007 and charged with considering the full range of eradication and control options for this organism irrespective of cost. Under the direction of CDFW, the San Francisco Estuary Institute performed a phased risk assessment of California waters in order to rank sites for further monitoring based on the likelihood that quagga or zebra mussels will become established.

There are a couple of relatively recent developments with respect to controlling quagga (and zebra) mussels. Recent research performed by a private company has demonstrated that a common soil bacteria, *Pseudomonas fluorescens*, when applied at artificially high densities, is effective at killing mussels, with a 95 percent kill rate reported at treatment sites (Science Daily 2007). Also, research is showing that a potassium salt solution may be an effective measure to control relatively localized and isolated infestations. Further research is being conducted on these treatment methods to determine whether or not these methods would be effective to control both zebra and quagga mussel populations.

Introduced Zooplankton. An extensive set of monitoring data from the Interagency Ecological Program (IEP) continues to show how introduced zooplankton species have become important elements of the Bay-Delta. *Eurytemora affinis* was probably introduced with striped bass around 1880. Until the late 1980s, it was a dominant calanoid copepod in the estuary, providing an important food source for juvenile fishes. In the last decade, however, *Eurytemora* has been replaced by two calanoid copepods introduced from China which appear to be less desirable as a food source. It has been postulated that this replacement was a result, in part, of *Eurytemora's* greater vulnerability to overbite clam grazing (Bouley and Kimmerer 2006).

Populations of the native mysid shrimp *Neomysis mercedis*, another form of zooplankton, began dwindling in the late 1970s and crashed in the late 1980s subsequent to the proliferation of the overbite clam. Its population decline was affected by competition with the smaller *Acanthomysis aspera*, an introduced mysid shrimp with similar feeding habits. The decline of the native shrimp species has been identified by the POD work team as one possible cause for the food web decline in the Delta (IEP 2007). Synthesis of IEP's extensive modeling data could help assess trends in rates of invasion and different invasive species populations.

Non-native Invasive Plants. Non-native aquatic weeds in the Delta pose serious problems to native flora and fauna. Research, monitoring, mapping, and control are needed for Brazilian waterweed (*Egeria densa)*, as well as South American spongeplant

(*Limnobium laevigatum*), water pennywort, Eurasian watermilfoil, parrot feather, and water hyacinth. These weeds flourish in a wide geographic area, sometimes in high densities, and are extremely harmful because of their ability to displace native plant species, harbor non-native predatory species, reduce food web productivity, reduce turbidity, or interfere with water conveyance and flood control systems. Areas with large densities of SAV have been implicated in reduced abundance of native fish larvae and adults (Grimaldo et al. 2004, Nobriga et al. 2005, Brown and Michniuk 2007). Restoration of habitats in intertidal areas must be designed and managed to reduce non-native SAV if conservation goals are to be met (Nobriga and Feyrer 2007).

The California Department of Boating and Waterways (CDBW) is the lead agency for the survey and control of *Egeria densa* and water hyacinth in the Delta. CDBW's control programs use two tools to determine coverage and biomass of these aquatic weeds: hyperspectral analysis and hydroaccoustic measurements. This technology has aided the assessment of *Egeria densa* coverage and biovolume, which in turn was instrumental in evaluating the effectiveness of mechanical and chemical treatment. A key asset of the technology is that it yields a very rapid, verifiable characterization of the entire water column beneath the transducer (Ruch and Kurt 2006). While this technology has been helpful in controlling localized patches of SAV, ongoing efforts of CDBW's control program may not be successful over time because other aquatic weeds (such as Eurasian watermilfoil or curlyleaf pondweed) may replace *Egeria densa*. Both of these plants have different growth properties that may require different control techniques than those currently employed in the control program (CDBW 2006).

Water management has focused on maintaining a common freshwater pool for water export and in-Delta agricultural use and has reduced the historical variability under which native species evolved. It is hypothesized, with uncertainty that periodic salinity shifts in the Delta may help to reduce the abundance and/or distribution of certain harmful invasive species, and give native species a competitive advantage. The Pelagic Fish Action Plan (IEP 2007) recommends the following actions to address invasive aquatic species in the estuary:

- Support California State Lands Commission's (CSLC) work to control ballast water, including CDFW oversight of studies to determine the location and geographic range of NIS in the estuary and assessment of ballast water controls.
- Assist CSLC, CDFW, and others in the development of regulations or control measures for hull-fouling.
- Support implementation of the CAISMP.

Other non-native plants that have been the focus of ERP NIS-related activities include giant reed (*Arundo donax)*, tamarisk (*Tamarix* spp), and purple loosestrife (*Lythrum salicaria*) in terrestrial areas. All three species displace native plants and alter riparian and wetland habitat structure and function, which results in unfavorable conditions for native wildlife species. In grassland communities, grazing has helped control the spread of some non-native invasive plants in some areas (Stromberg et al. 2007).

Water and Sediment Quality

Dissolved Oxygen. A sufficient level of dissolved oxygen (DO) is critical to the health and survival of aquatic species. Oxygen depletion is exacerbated by warm water temperatures, since warm water holds less DO than cold water. DO concentrations typically are lowest during the summer when river temperatures are warmer. The occurrence of decomposing aquatic vegetation, poor channel geometry, low streamflow, poor mixing of the stream water with the atmosphere, and the presence of oxygen-depleting substances (e.g., sewage, animal waste, ammonia, organic nitrogen, and algae), can also contribute to diminished DO conditions.

The optimum range of DO for fish and aquatic life is 5-9 mg/L (DFG 2010e). When DO levels drop below this range, behaviors such as feeding, migration, predator avoidance, and reproduction are negatively affected for some fish species. DO levels approaching 2 mg/L can serve as a barrier to fish migration and can negatively impact food web organisms (DFG 2010e). When DO concentrations are reduced to a level that is detrimental to aquatic organisms, hypoxia (oxygen deprivation) occurs. Sub-lethal effects of hypoxia may include malformed or delayed fish embryonic development or altered balance of sex hormones during embryonic stages. Subsequent sexual development may also be affected. Studies show that hypoxia can cause endocrine disruption in adult fish (Wu et al. 2003, Thomas et al. 2007). Impairment at earlier life cycle stages may subsequently reduce the fitness and chance of survival of individuals in natural populations (Shang and Wu 2004).

There is evidence that low DO levels in the San Joaquin River Deep Water Ship Channel (DWSC) can create a migration barrier for adult fall-run Chinook salmon. In addition to impairment of fish production, migration, and juvenile rearing, low DO is a potential cause of mortality in other aquatic organisms (CALFED 2000a, b). Low DO levels may negatively affect San Joaquin River benthic and water column biotic communities and ecological processes (CALFED 2000a) with implications for the aquatic food web and quality of aquatic habitat. The Central Valley Regional Water Quality Control Board adopted a phased TMDL program for the lower San Joaquin River in 2005. Additional studies toward development of a final TMDL that also addresses both estuarine and upstream areas are underway. A barrier is installed in the fall each year to increase flow in the mainstem San Joaquin River and improve DO conditions in the vicinity of Stockton.

Earlier studies funded by the ERP during Stage 1 identified three main contributing factors to the low DO levels in the DWSC: 1) loading of oxygen-demanding substances from upstream sources that react by numerous chemical, biological, and physical mechanisms to remove DO from the water column; 2) DWSC geometry impacts that add or remove DO from the water column, resulting in increased net oxygen demand; and 3) reduced flow through the DWSC that adds or removes DO from the water column, resulting in increased net oxygen demand (DFG 2010e, San Joaquin River DO Technical Working Group 2007.) Low DO can also facilitate blooms of toxic blue-green algae or exacerbate negative impacts to organisms of other toxic chemicals in the water column. In addition to negative impacts to species in the vicinity of the lower San Joaquin River and DWSC, low DO appears to be a problem for aquatic species in the Suisun Marsh. Evidence of fish kills and early results of some studies indicate that low DO in water and drainage from managed wetlands are significant threats to aquatic species in the Suisun Marsh and Bay (DFG 2010e).

The Central Valley Regional Water Quality Control Board has assembled extensive data on the DO problem through the TMDL for DO in the DWSC. Since the SWRCB approved the TMDL, the City of Stockton added two nitrifying bio-towers and engineered wetlands to the Stockton Regional Wastewater Control Facility to reduce ammonia discharges to the San Joaquin River. The DWR constructed a demonstration aeration facility at Rough and Ready Island to determine its effectiveness for improving DO conditions in the DWSC (DWR 2010). Drainage reduction efforts upstream have significantly reduced oxygen demanding substances entering the DWSC. As a result, conditions have improved dramatically, with far fewer, less frequent, and less severe excursions. The major DO sags no longer occur (DWR 2011; CVRWQCB 2011). Still, low DO continues to be a problem in the lower San Joaquin River at the Stockton DWSC and occasionally in the Suisun Marsh when managed wetlands are drained into dead-end sloughs. The ERP Implementing Agencies will continue to work cooperatively with the Water Boards in updating Basin Plans and taking actions to meet mutual goals for improving DO conditions in the Delta.

Turbidity. Turbidity is a measure of how much material suspended in water decreases the passage of light through the water. Studies have indicated that juvenile and adult delta smelt distribution is well predicted by turbidity of the water (Nobriga et al. 2008, Feyrer et al. 2007), and that turbidity serves as an environmental trigger for upstream migration of delta smelt (Grimaldo et al. 2009). Turbidity is known to reduce predation risk to migrating Chinook salmon in other estuaries such as the Fraser River (Gregory 1993). The current growth and spread of SAV in the Delta is likely controlled by water velocities, rather than light availability (Hestir 2010). In clear water, *Egeria densa* can grow to depths of 6 m (Anderson and Hoshovsky 2000). According to Hestir (2010), Delta SAV grows best at annual water velocities below 0.49 m/s and suppresses turbidity levels in its vicinity by reducing sediment resuspension. The expansion of invasive SAV in the Delta can explain 21–71% of the total increasing trend in water clarity in the Delta from 1975–2008. Although *Egeria densa* may have reached the current limits of its distribution in the Delta, it is possible that additional clearing due to further reductions in sediment supplies and water velocities will allow *Egeria densa* to spread into progressively deeper water and contribute to even more clearing.

Contaminants. Contaminants are organic and inorganic chemicals, biological pathogens, and metabolites that can cause adverse physiological response in humans, plants, fish, and wildlife through waterborne or food-chain exposure. Contamination by these compounds may cause acute toxicity and mortality or long-term toxicity and associated detrimental physiological responses, such as reduced growth or reproductive impairment. Contaminant effects are species specific. Some are more likely to affect lower trophic levels with potential negative effects on species composition and food web dynamics. At higher trophic levels, toxic effects are less likely to be lethal. But sub lethal toxicity may reduce ecological fitness (Werner et al. 2008).

Contaminant loadings from the watersheds have a significant effect on the Delta ecosystem. Pesticides applied in agricultural and residential landscapes, metals and toxins from industrial facilities or transported via storm water runoff from roads, parking lots, and highways, mercury from historical mining activities, selenium from agricultural drainage, and ammonia and other nutrients from sewage outfalls, all significantly affect living organisms in the Delta. Controlling these contaminants at their sources must be an important component of ecosystem restoration.

Pesticides and Endocrine Disrupting Chemicals. A wide variety of pesticides as well as herbicides, fungicides, and algicides enter the Delta from many sources. Each has the potential to adversely affect species in the Delta. Since CALFED ERP implementation began in 2000, pesticide use has changed from being dominated by organophosphate (OP) pesticides, such as diazinon and chlorpyrifos, to increased use of pyrethroid pesticides. Pyrethroid pesticides are more difficult to detect in water due to their tendency to adsorb strongly to sediment particles and partition out of the water column. Pyrethroid pesticides can have sub lethal effects to aquatic vertebrates and lethal effects to invertebrates, and are believed to be one of the factors contributing to the POD. Preliminary data suggest that both OP and pyrethroid pesticides were responsible for a higher incidence of toxic water quality events in 2007, a dry water year (IEP 2008). Recent results from studies indicate that pyrethroids are causing significant toxicity to benthic organisms in 25-60 percent of tested water bodies, particularly creeks and storm drains. Other studies show that very low concentrations of OP pesticides may interfere with sensory cues needed for salmonid migration (DFG 2010e). Laboratory studies of salmon with sub lethal exposures to pyrethroids show significant increased susceptibility to death from disease (DFG 2010e).

Contaminants toxic to fish and wildlife could be reduced by changing land management practices and chemical uses on urban and agricultural lands that drain into the Delta. The effects of these contaminants need to be viewed from an ecosystem perspective. However, in order to characterize ecosystem effects, individual components such as fate and transport, distribution and concentrations throughout the watershed, toxicity to individual species, and other parameters need to be defined and better understood (DFG 2010e). Sub lethal impacts on fish and food web organism populations are difficult to document, since these impacts do not result in immediate mortality. Thus, assumptions about cause-and-effect relationships must be made. Monitoring shows that many Central Valley waterways contain high levels of agricultural and urban discharges. Predominant pesticides detected throughout Central Valley waterways were diazinon, chlorpyrifos, the herbicides simazine and diuron, and DDT breakdown products (CVRWQCB 2007).

Scientists are increasingly concerned about some contaminants because they act as endocrine disrupters in humans or animals. Diethylstilbestrol (the drug DES) and certain pesticides (e.g., dioxin, PCBs, and DDT) are known endocrine disrupters in humans. In addition, plasticizers such as polybrominated diphenyl ethers (PBDEs) used as a fire retardant in furniture, televisions, and computers may bioaccumulate in fish and result in sub lethal toxic effects. Studies conducted as part of IEP's POD investigations showed some evidence of low frequency endocrine disruption in adult delta smelt males, likely due to exposure to endocrine disrupting chemicals (EDCs) in the water column. In 2005, six percent of individuals were intersex, with immature oocytes in their testes (IEP 2008).

The length of time during which toxicity remains in the system is an important aspect of water quality contamination because of the potential for resident organisms increased exposure and subsequent chronic effects. Delta sloughs, and the organisms that live in them, are particularly susceptible because of longer water residence time. Quarterly monitoring results show that several Delta sloughs receiving both urban and agricultural runoff, notably French Camp and Paradise Cut, had toxicity that persisted for up to 15 days (DFG 2010e). In light of the expressed management objective to enhance heterogeneity of habitats throughout the Delta during Stage 2 of ERP implementation, in part by increasing the residence time of water in channels and sloughs, toxicity will need to be evaluated in terms of individual contaminants and the species that may be affected.

The ERP needs to continue to coordinate with the Water Boards and the Department of Pesticide Regulation (DPR) to assess progress on this issue and to track future actions planned by these agencies. After obtaining this information, the agencies can identify funding opportunities to support recommended remediation measures. More specifically, continued studies are needed to further investigate pesticide residence time in Delta sloughs due to both urban and agricultural runoff. Continued funding for toxicity identification evaluations (TIE) development, with respect to water quality monitoring, is also crucial to understanding the effects of the varying pesticide practices and applications used throughout the Central Valley. Focused monitoring to investigate possible sources in small urban and agriculturally impacted creeks or drains is necessary to continue reduction of pesticides. Financial support is also needed to continue development and implementation of BMPs for pesticide use as well as provide for public outreach and education. Mosquito control BMPs will be included in Delta restoration projects. It is important to address factors that contribute to pesticide use. Implementing practices that minimize vector production can significantly reduce the need for public health pesticide use.

Ammonia. In water, ammonia primarily exists in two forms, un-ionized ammonia (NH_3) and ammonium ion (NH_4^+), which are in equilibrium according to $NH_4^+ \leftrightarrow NH_3 + H^+$. The equilibrium between un-ionized ammonia and ammonium depends primarily on pH, and to a lesser extent on temperature and salinity. Both ammonium and un-ionized ammonia are present in effluent from wastewater treatment plants that employ secondary treatment methods. Additional sources of ammonium to the Delta include agricultural and urban run-off, atmospheric deposition, internal cycling, and possibly discharges from wetlands. The role of ammonia in aquatic ecosystems of the Delta has been a topic of much recent interest.

Recent work has shown that elevated ammonium concentrations can suppress primary production, even when there is sufficient light, by inhibiting uptake of nitrate (Wilkerson et al. 2006, Dugdale et al. 2007, Parker et al. 2010). However, the food web effects of ammonium in the Delta are not fully resolved and remain a focus of active research. Low light availability and high grazing rates have been identified as important factors controlling overall phytoplankton production and biomass in the Delta, while nutrients were generally thought to be of lesser importance in this turbid, nutrient-rich estuary. The sudden clearing of estuarine waters of San Francisco Bay after 1999 (Schoellhamer 2011) has led to concern that this paradigm may be shifting to one where nutrients play an increasingly important role in regulating productivity as they do in other estuaries (Paerl 2009). The role of ammonium in the proliferation of non-native rooted and floating aquatic plants, particularly *Egeria densa* and water hyacinth (*Eichhornia crassipes*), and the emergence of harmful algal blooms (e.g., *Microcystis*) in the Delta also remain as important questions.

Mercury and Methylmercury. Mercury is a toxic metal that has no known beneficial biological function in fish, birds, or mammals (Wiener et al. 2003). Historical mercury mining in the Coast Range and mercury use associated with gold mining in the Sierra Nevada have left an environmental legacy of pervasive mercury contamination in many northern California watersheds. Under certain environmental conditions, inorganic mercury can be converted by microbial activity to methylmercury, a more toxic, organic form of mercury that readily bioaccumulates (increases in concentration) in aquatic and terrestrial food webs. Because methylmercury bioaccumulates with each step up the food chain, the species at greatest risk to exposure are top predators including fish like largemouth bass, striped bass and sturgeon, fish-eating birds like eagles, and humans (Alpers 2007).

Some habitats more readily facilitate mercury methylation, resulting in greater wildlife exposure. These habitats include high tidal marsh, seasonal wetlands, and floodplains. Perennial aquatic habitats and low tidal areas have relatively lower methylation potential. A working hypothesis that explains these variations recognizes that these higher elevation methylmercury habitats have extended dry periods in which soil and sediment completely dry out. This raises the possibility that oxidation of mercury during the dry periods will lead to higher concentrations of reactive mercury during subsequent flooding, when sulfate- or iron-reducing bacteria facilitate methylation. The oxidation of carbon and sulfur compounds during dry periods may also play an important role in increasing mercury methylation rates during subsequent flooding (Alpers 2007).

Before ERP implementation began in 2000, a favored working hypothesis among mercury scientists was that the Delta would be a zone of net mercury methylation. Since then, water and fish monitoring data have shown that the central Delta is actually lower in methylmercury concentration than tributary areas (e.g., the Yolo Bypass and Sacramento, Cosumnes, and San Joaquin rivers). Preliminary mass balance calculations indicate a net loss of methylmercury in water as it flows through the Delta (Foe et al. 2003, CVRWQCB 2006). This methylmercury loss may be caused by breakdown of methylmercury from photodemethylation (exposure to light) or by sedimentation (adsorbing to particles and settling out of the water column) (Stephenson et al. 2007). Another possible contributing factor is that high concentrations of reduced sulfur may make reactive forms of mercury less available to the methylation process. Mercury demethylation processes may be important in the Delta, although additional study is needed to quantify these processes (Alpers 2007).

The Fish Mercury Project was funded by CALFED in 2004 to characterize the mercury concentrations in sport fish to assess the spatial and temporal trends in mercury concentrations of fish in the Bay-Delta and to support development of new consumption advisories (also known as safe eating guidelines). Approximately 1400 fish from 30 species were collected from 47 popular sport fishing locations in the Bay-Delta watershed. Clear regional patterns in sport fish mercury concentrations were apparent in some species. In general, mercury concentrations were highest at locations in the north Delta and in the southern portion of the Sacramento River (north of the Delta to Butte Creek) and its tributaries. Locations in the northern portion of the watershed (Butte Creek to Lake Shasta) had consistently lower concentrations. For example, largemouth bass mercury concentrations in the north Delta were typically around 0.5 ppm, with some locations along tributaries to the lower portion of the Sacramento River exceeding 0.6 ppm. In the northern portion of the watershed, however, the majority of locations ranged from 0.2 to 0.4 ppm. The data from these sites were used by the Office of Environmental Health Hazard Assessment to develop consumption advisories (OEHHA 2007). Consumption advisories provide information to sport fish consumers to assist them in choosing which fish are low in contaminants.

Due to high levels of mercury throughout the Bay-Delta watershed, the Central Valley and San Francisco Bay Regional Water Quality Control Boards have been developing TMDLs in an effort to reduce amounts of this constituent. Recently, the Central Valley Regional Water Quality Control Board adopted a methylmercury TMDL for the Delta (CVRWQCB 2010). If current regulatory trends continue, TMDLs for mercury and methylmercury in San Francisco Bay, the Delta, and their tributaries will be key drivers of mercury research, monitoring, and remediation over the next several years (Alpers 2007). Improvement of the sediment trapping efficiency of the Cache Creek Settling Basin was identified as one of the most cost-effective ways to reduce loads of mercury and methylmercury in the Yolo Bypass, one of the largest contributors of these contaminants to the Delta and areas downstream to San Francisco Bay (CVRWQCB 2006, 2010). A redesign of the Basin to include Knights Landing Ridge Cut would greatly help solve salmonid and green sturgeon entrainment problems in Yolo Bypass and would reduce concerns of mercury methylation from restoration efforts in Yolo Bypass.

Reducing methylmercury production and/or translocation is key to reducing its concentration in Delta waterways. Management tools to minimize methylmercury formation include:

- Participating in the Water Boards TMDL programs for mercury and methylmercury in the Delta.
- Developing and implementing TMDLs in areas upstream of the Delta to reduce loads of organic and inorganic mercury entering the Delta from tributary sources.
- Developing BMPs to control the production of methylmercury at aquatic habitat sites, and to control the transport of methylmercury into the system.

There are a number of uncertainties which managers must be mindful of, both in terms of the anticipated impacts of regional climate change and the desired recovery of species through restoration of ecological processes and habitats in the Delta. Changes in water clarity associated with changes in hydrology will likely affect the efficiency of mercury photodemethylation. For example, an increase in turbidity or dissolved organic carbon will decrease light penetration, which will decrease the rate of photodemethylation. Therefore, ecosystem restoration projects that might cause increased turbidity should be carefully monitored for impacts on net mercury methylation and bioaccumulation. There is also a possibility that future changes in nutrient management and hydrology could result in a significant increase in primary production that will be of great benefit in reversing the POD. Associated changes in concentrations of dissolved and particulate organic matter and their complex interactions with mercury methylation processes are difficult to predict. Nevertheless, if methylmercury production rates were to remain constant or increase at a slower rate than the increase in primary productivity, then concentrations of methylmercury could decline at the base of the food web because of biodilution, which would likely result in lower levels of mercury bioaccumulation throughout the food web. Potential increases in algae would need to be controlled so as not to occur in areas already experiencing problems with DO, because algal decay consumes oxygen (Alpers 2007).

There is a general concern that increased concentrations of methylmercury in water, sediment, and biota might result from any of several types of actions being taken or contemplated by ERP, including wetland and floodplain habitat restoration in the Bay-Delta and changes in the fresh water conveyance across the Delta. In accordance with the TMDL under development for the Delta, ongoing studies at the Yolo Bypass Wildlife Area include the development of BMPs to manage habitats in ways that avoid or minimize potential methylation of mercury at restoration sites. In general, potential mercury methylation from actions to create or enhance important aquatic habitats, or from other actions geared toward increasing turbidity or primary production, must be weighed against the negative impacts associated with not restoring critical aquatic habitat types and recover species.

Selenium. Selenium is a naturally-occurring semi-metal that is widely distributed in the earth's crust. It is naturally abundant in the marine shale sedimentary rocks and soils weathered from the rocks of the Coast Ranges west of the San Joaquin Valley. Irrigation water applied to these erosion-derived agricultural soils leaches selenium from the soil, which then enters surface water carried by irrigation return flows. Refineries in the San Francisco Bay area also contribute selenium to the ecosystem.

Selenium can be highly toxic to aquatic life at relatively low concentrations. Conversely, it is also an essential trace nutrient for many aquatic and terrestrial species. The range between these two effects is narrow. Adequate human dietary levels are generally around 0.1-0.3 ug/g, but the toxicity threshold for sensitive organisms is around 2.0 ug/g. Selenium can bioaccumulate in the food web.

Ecological effects of selenium are largely governed by dry season and low flow conditions. This is when selenium concentrations are highest. Documented effects of selenium toxicity include deformities in white sturgeon larvae and the inability of white sturgeon eggs to hatch. Reproductive effects of selenium on white sturgeon are highest in Suisun Bay during fall and early winter, coinciding with the "first flush" rain event. It is believed that mature splittail may also be adversely affected by selenium (Luoma and Rainbow 2008).

Changes in Delta infrastructure and conveyance could result in different transport routes, source mixtures, and flushing times of water and contaminants within the Delta (Monsen et al. 2007). Conveying fresh Sacramento River water around the Delta, for example, could result in a higher amount of San Joaquin River water flowing into the estuary.

Several efforts are underway to revise and expand standards for selenium in the Bay Delta Estuary. At the national level, US EPA plans to propose Clean Water Act Section 304(a) selenium guidance criteria for aquatic life for freshwater. The guidance criteria will include chronic values only, and will distinguish between flowing and standing waters. These guidance criteria will form the basis for adopting protective water quality standards expressed as tissue concentration of selenium in fish egg or ovary and a corresponding water column concentration, where tissue concentration data are not available. Concentrations in tissue, such as bird eggs or fish tissue better indicate actual exposure and, in combination with food web information, provide a basis for deriving site-specific numeric water column values.

The revised national guidance criteria will be supplemented by regional efforts. US EPA Region 9, in conjunction with the USGS, USFWS, and NMFS, and pursuant to its obligations under the ESA, is developing criteria to protect threatened and endangered wildlife species, aquatic-dependent species and aquatic life in California. The first phase of this effort addresses the San Francisco Bay and Delta. It uses data on affected species and relies on the Presser-Luoma ecosystem-based model (Presser and Luoma 2006), a model that accounts for food web processes and site-specific conditions.

Metals. Metals such as copper and nickel also are being investigated for their potential effects on species. Dissolved copper concentrations are elevated in the estuary where its toxic effects are not buffered by organic ligands, like in the more saline waters of the Bay (Werner et al. 2008). Copper enters the aquatic environment from urban stormwater runoff (winter/spring), agricultural applications, herbicide treatments of SAV (mainly summer), and as a heritage contaminant from mining activities. Nickel, primarily from urban runoff, may also have effects on species. Synthetic organometallic compounds such as tributyltin (TBT), used in antifoulant paints for boats, are highly toxic to aquatic invertebrates (Werner et al. 2008).

Key steps in successfully improving Delta water and sediment quality include:

- Developing a regulatory approach that can expeditiously address emerging contaminant problems as they are identified.
- Implementing advanced treatment at wastewater treatment plants discharging to Delta source waters and implementing source control programs for their service areas.
- Implementing BMPs and source controls necessary to meet water quality objectives, including for habitat restoration projects.
- Implementing BMPs for agricultural discharges to reduce pesticides and other contaminant loads, and for all agricultural activities.
- Developing land use policies that ensure adequate protection of waterways from non-point source contamination, including mandatory buffer areas between urban or agricultural development, and waterways to allow percolation of run-off.
- Participate in remediation of mine sites as part of local watershed restoration and Delta restoration.

Water Diversions and Barriers

Water Diversions and Barriers. The ERP Strategic Plan did not specifically outline an objective for the impacts from water diversions and barriers (such as dams). However, ERPP volume 1 included vision statements to address the adverse impacts of these stressors.

Water diversions affect the Delta ecosystem in two fundamental ways: 1) through entrainment of fish and other aquatic organisms, and 2) through alteration of water flow circulation patterns which leads to changes in water quality and Delta habitats. Entrainment and impingement of fish and organisms can occur at diversions of any size, but are believed to be a problem mainly at those diversions that are relatively large in comparison to the channels from which they are drawing water. Alteration of water circulation patterns in the Delta occurs at several locations. Adult fish migrating into the Sacramento DWSC can become blocked from upstream areas without flows to attract the fish back into the mainstem river (Vogel 2011). The Delta Cross Channel provides a connection between the mainstem Sacramento River and the North Fork Mokelumne River, which was constructed to protect drinking water quality (by controlling salinity) and improve the efficiency of water export operations. Other examples include a barrier at the head of Old River operated seasonally to direct emigrating salmon smolts away from the export pumps in the spring, and improve DO conditions in the San Joaquin River in the fall to facilitate the upstream movement of adult salmon.

There are approximately 3000 water diversions in the Delta (SWRCB 2012b). Most of them are small (<100 cubic feet per second [cfs]) and provide water seasonally to agricultural parcels. The ERP Strategic Plan states that it is unclear how important the

Delta's agricultural diversions are as a source of mortality for fish. Nobriga et al. (2004) conclude that small Delta agricultural diversions are likely to have a minor impact on pelagic (open water) fishes such as delta smelt because the hydrodynamic influence of such diversions is small and pelagic fish are primarily distributed outside the zone of influence. Fish screens on small diversions were not widely pursued in the Delta during ERP Stage 1, primarily due to high costs and low native fish population benefits compared to larger screening projects (i.e., screens to protect anadromous fish at larger upstream diversions). A prioritized list of criteria for potential fish screen projects upstream of the Delta was generated by the Anadromous Fish Screen Program (AFSP) authorized under the CVPIA, and will be used to evaluate mostly larger (>250 cfs) fish screen projects in the future. A team of State and Federal fish screen experts hold regular workshops to share information, discuss upcoming projects, and discuss priorities for future fish screen projects.

The largest water diversions in the Delta are the export facilities for the SWP and CVP in the south Delta. There are two power plants in Antioch and Pittsburg that historically diverted large amounts of water, and several diversions that supply water to Contra Costa Water District serving cities outside of the Delta. The Contra Costa and Pittsburg Power Plant diversions are believed to have relatively small impacts on rearing and outmigrating juvenile winter-run salmon and steelhead, and medium impacts on rearing and outmigrating spring-run and fall or late-fall run Chinook (DWR 2005). Their impacts on delta and longfin smelt are uncertain. Non-consumptive (flow-through cooling) water use by these diversions approach 3,200 cfs at times, possibly enough to create a substantial entrainment risk. Operations have been modified at the plants in recent years to reduce flow-through water use, and the entrainment risk for both salmon and smelt.

While it remains very difficult to precisely quantify the relative contribution of export operations to recent fish declines (Kimmerer and Nobriga 2008), there is a growing body of evidence that indicates water exports are making a significant contribution through a combination of entrainment as well as habitat effects (USFWS 2008, NMFS 2009a). Export operations can substantially affect water movement through Delta channels and may result in net reverse flows in Old and Middle rivers, and other channels and sloughs near the export facilities when export levels are high and river inflows are low. Changes in hydrodynamics, notably reverse flows, have direct effects on fish by transporting them toward the export pumps or providing incorrect cues to the direction of "downstream", increasing their risk of entrainment. While there is great effort put into salvaging fish from the export facilities and returning them to suitable Delta habitats, the low detection of entrained fish in salvage due to high pre-screen losses (e.g. Gingras 1997, Clark et al. 2009, Castillo et al. 2012) combined with low population sizes of listed species may hinder the ability to evaluate the effectiveness of incidental take (Anderson et al. 2011). Several alternatives for reducing the SWP pre-screen losses for Chinook salmon, steelhead, delta smelt and other native fishes entrained in Clifton Court Forebay have been suggested over the last two decades (Kano 1990, USFWS 1996, Gingras 1997, Clark et al. 2009, Castillo et al. 2012).

Newman (2008) concluded that outmigrating salmon from the Sacramento River had reduced survival when the Delta Cross Channel was open.

The ERP Strategic Plan stated that it is unclear to what extent and by what mechanisms SWP and CVP export operations affect the population size of any one species of fish or other biota. However, previously assumed pre-screen losses for delta smelt at the SWP may have been underestimated. Castillo et al. (2012) reported that the greatest source of mortality for delta smelt entrained at the SWP export facilities was pre-screen loss in Clifton Court Forebay (94.6% to 99.9%). They concluded that salvage of delta smelt at the SWP does not seem to be a consistent index of entrainment, presumably due to the high variability in residence time of the water entrained in the forebay.

Net reverse flow in Old and Middle rivers in winter months, a function of San Joaquin River flow into the Delta as well as SWP/CVP pumping rates and tides, is strongly correlated with entrainment of adult delta smelt (Grimaldo et al. 2009, Kimmerer 2008). Due to their small size, delta smelt larvae are currently not salvaged or sampled effectively. Therefore, particle modeling studies have been used to demonstrate that reverse flows also result in high levels of larval entrainment (Kimmerer and Nobriga 2008, Kimmerer 2008). To protect delta smelt from the effects of reverse flows, limitations on Old and Middle rivers flow were included in the USFWS OCAP Biological Opinion for delta smelt (USFWS 2008).

Recent analyses correlating SWP and CVP salvage with population indices show an estimated loss rate of migrating juvenile Chinook salmon of 10 percent or less, depending on pre-screen mortality (Kimmerer 2008). From a population perspective, this calculated loss rate at the export facilities is a significant element of direct anthropogenic mortality. Similar analyses for delta smelt show that pre-spawning adults, as well as larvae and early juveniles, may suffer substantial losses. A combination of the results for these life stages indicate delta smelt losses can be as high as 40 percent of the population throughout winter and spring (Kimmerer 2008). High winter entrainment has been suspected as a contributing cause of both the early 1980s (Moyle et al. 1992) and the POD-era declines of delta smelt (Baxter et al. 2008). Ongoing analysis by the IEP in its evaluation of the POD asserts that substantial increases in winter SWP and CVP salvage occurred contemporaneously with the recent decline in pelagic species, suggesting that the SWP and CVP diversions played a role in the POD. Multiple, substantial efforts are currently underway to develop and use species life cycle models to facilitate assessment of the relative and absolute population effects of various stressors.

Studies also indicate that indirect causes of mortality to the Delta's aquatic organisms may be due to hydrologic effects of the SWP and CVP pumps and flow barriers. These facilities have been determined to cause changes in flushing time and transport routes, which results in alteration of salinity and DO levels in certain areas of the Delta (Monsen et al. 2007). Changes to water quality parameters are likely to affect habitat for aquatic organisms. Water exports may also reduce residence time, increasing the rate at which water is transported through Delta channels, which affects primary and secondary production (DFG 2010e).

Currently, the SWP and CVP must comply with Water Board Decision 1641 (D-1641), which regulates the proportion of water that can be exported in relation to the amount of water entering the Delta (export to inflow, or E/I ratio). E/I ratios are permitted to be a maximum of 65 percent from July through December, and a maximum of 35 percent from February through June when Delta inflows are typically higher (NMFS 2009a). The E/I ratio is used in management of Delta aquatic resources because it measures the influence of SWP and CVP diversions (Newman and Rice 2002, Kimmerer and Nobriga 2008). Kimmerer and Nobriga (2008) evaluated the E/I ratio as a predictor of entrainment probability for neutrally buoyant particles to represent larval fish using a two-dimensional model and associated particle tracking model developed by DWR. The E/I ratio was found to be useful as a predictor of entrainment probability for organisms with limited mobility, although the model may be less applicable to more competent swimmers such as salmon smolts. Significant SWP/CVP entrainment of particles injected into the south and eastern Delta occurred at E/I rations of 0.2 and above. One criticism of using the E/I ratio to manage effects on Delta fish is that the actual volume of exports can increase substantially while maintaining the same overall E/I ratio as inflow increases. Better resolution of the relationship(s) between salvage and E/I ratio may be achieved if either the export or inflow term is held constant (NMFS 2009a). Due to their very large hydrodynamic footprint, reducing the negative effects of the SWP and CVP pumps cannot be accomplished only through screening and will depend in part on an alternative water conveyance system that does not involve drawing Sacramento River water across the Delta.

Hatchery Management. Fish hatcheries in the Central Valley were constructed to mitigate for habitat loss associated with the construction of many of the major dams. Downstream consequences of dam construction include water temperature changes, flow modification/disruption/diversion, and diminished spawning gravel recruitment and floodplain and riparian habitat, which in combination have affected productivity of natural populations of salmon and steelhead in their remaining accessible habitat.

Most anadromous fish hatchery programs in California are operated to mitigate for lost habitat and decreased production capacity of wild populations caused by dam construction. However, there have been some unintended consequences resulting from the ways hatcheries have been managed. Genetic and ecological interactions of hatchery and wild fish have been identified as risk factors for wild populations, and high harvest rates directed at hatchery fish may cause over-exploitation of commingled wild stocks. Hatcheries must have a larger role than simply producing and releasing defined numbers of juvenile fishes, and mitigators have a greater responsibility to help maintain, and in some cases rebuild, healthy naturally producing populations of anadromous fish.

In 2010, Congress appropriated funds for and expanded the geographical scope of the California Hatchery Scientific Review Project. The goal of this hatchery program review was to ensure that hatchery programs are managed and operated to meet one or both of the primary purposes for hatcheries: helping recover and conserve naturally spawning salmon and steelhead populations, and supporting sustainable fisheries with little or no deleterious consequence to natural populations. The findings of the program review were finalized in the California Hatchery Review Report in June 2012. The findings and recommendations included within that report were intended to provide guidance to policy makers who will be responsible for implementing changes in how California hatcheries are operated (California HSRG 2012).

Subsidence Reversal. The exposure of the bare peat soils to air causes oxidation and decomposition, which results in subsidence, or a loss of soil elevation, on Delta islands. Flooding these lands and managing them as wetlands reduces their exposure to oxygen, so there is less decomposition of organic matter, which stabilizes land elevations. Wetland vegetation cycles lead to biomass accumulation, which sequesters carbon and helps stop and reverse subsidence (Fujii 2007). As subsidence is reversed, land elevations increase and accommodation space (the space in the Delta that lies below sea level and is filled with neither sediment nor water), on individual islands is reduced (Mount and Twiss 2005). A reduction in accommodation space decreases the potential for drinking water quality impacts from salinity intrusion in the case of one or more levee breaks on deeply subsided Delta islands.

A pilot study on Twitchell Island funded by ERP in the late 1990s investigated methods for minimizing or reversing subsidence. The study showed that by flooding soils on subsided islands approximately one foot deep, peat soil decomposition is stopped, and conditions are ideal for emergent marsh vegetation to become established. In the Twitchell Island pilot project, researchers saw some initial soil accumulation during the late 1990s and early 2000s, and noted that accretion rates accelerated and land surface elevation began increasing much more rapidly after about seven years, as plant biomass was accumulated over time. Land surface elevation is estimated to be increasing at an annual rate of around four inches, and is expected to continue to increase (Fujii 2007).

The United States Geological Survey (USGS) is interested in implementing a subsidence reversal program Delta-wide, given the results of the Twitchell Island pilot study. Such a program would involve offering financial incentives to landowners to create and manage wetland areas on their lands (Fujii 2007). Large-scale, whole-island approaches to reversing subsidence would be beneficial for multiple purposes. Programs that offer incentives for 10- or 20-year studies for subsidence reversal on large tracts of land could help improve Delta levee stability and reduce the risk of catastrophic failure. Assuming that accretion rates continue at about four inches annually, estimates suggest a 50 percent reduction in accommodation space in 50 years if subsidence could be pursued throughout the Delta. This reduction in accommodation space jumps to 99 percent over the next 100 years (Fujii 2007). Some deeply subsided lands could also be used as disposal sites for clean dredged sediments, providing local flood control improvements while helping raise land elevations on subsided islands more quickly. This accommodation space reduction, in addition to helping stabilize levees over the longer term, would create additional areas for restoration of additional tidal marsh habitat.

While the primary objectives of creating wetlands on deep Delta islands would be to reverse subsidence and sequester carbon, there would be significant ancillary benefits to wildlife such as waterfowl. Delta agricultural lands and managed wetland areas provide a vital component to Pacific Flyway habitat for migratory waterfowl by increasing the availability of natural forage, ensuring improved body condition and breeding success (CALFED 2000b).

Terrestrial areas in this category include mainly agricultural lands, some of which are not in active agricultural production. Central Valley Joint Venture recognizes that agricultural easements to maintain waterfowl food supplies and buffer existing wetlands from urban development may become increasingly important in basins where large increases in human populations are predicted (CVJV 2006). In addition, ongoing rice cultivation may help minimize subsidence. Subsidence reversal, carbon sequestration, and wildlife-friendly agricultural projects are appropriate on these deep islands in the near term, as they are expected to provide benefits to the local economy, wildlife, and waterfowl while protecting lands from uses that may be unsustainable over the longer term.

The rationales for protection and enhancement of seasonal wetlands and wildlife-friendly agriculture are contained in the ERPP, and the reader is encouraged to refer to these volumes for more information (CALFED 2000b). For the purposes of this document, the discussion on restoring habitats on subsided lands will be focused on subsidence reversal and carbon sequestration, and on continuing to research and restore deep open water areas for the Delta's pelagic fish species, as these deep open water habitat types are known to be important, positively or negatively, for individual native pelagic fish species.

IV. Species

ERP Goal 1 (Endangered and Other At-risk Species and Native Biotic Communities) is to initiate recovery of at‑risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self‑sustaining populations of these species; support similar recovery of at‑risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed. ERP intends to continue working toward species recovery by focusing on restoring environmental processes, creating suitable habitat areas, and reducing stressors, rather than taking a narrow species-by-species approach to conservation. There is an understanding, however, that species-specific options should remain open to ensure individual species recovery. Diversifying the array of tools that managers have available to them to improve the resilience of species in a changing environment will reduce the risks associated with uncertainties. However, new literature suggests that the species-by-species approach to conservation becomes particularly important when a system has been altered so drastically that the full restoration of fundamental ecosystem processes is unlikely. Balanced implementation will be mindful of this apparent contradiction and proceed while offsetting the uncertainties using adaptive management principles.

Species population viability is generally assessed through four factors: 1) species and life stage abundance; 2) productivity or reproductive rate; 3) spatial distribution; and 4) genetic diversity. All of these factors need to be kept in mind as managers look for tools they can utilize to increase species viability and resilience in light of the Delta's unpredictable dynamic conditions.

The species-by-species sections below are examples of the ERP Stage 1 and the Delta Science Program recent research findings that have increased our understanding of specific species population dynamics and responses to stressors. These and other findings provide the basis for more effective restoration planning and implementation.

Delta Smelt. Delta smelt (*Hypomesus transpacificus*) are slender-bodied fish, generally reaching about 60 to 85 millimeters (mm) at age 1 and 90-110 mm at age 2 (Bennett 2005). They feed primarily on small planktonic (free floating) crustaceans, and occasionally on insect larvae (Moyle 2002). Their historical range is thought to have extended from San Pablo Bay upstream to at least the city of Sacramento on the Sacramento River and the city of Mossdale on the San Joaquin River. They were once one of the most common pelagic (living in open water away from the bottom) fish in the upper Sacramento–San Joaquin Estuary (Moyle 2002).

Studies indicate that delta smelt require specific environmental conditions (freshwater flow, water quality) and habitat types (shallow open waters) within the estuary for migration, spawning, egg incubation, rearing, and larval and juvenile transport from spawning to rearing habitats (Moyle 2002). In September or October, delta smelt reach adulthood and begin a gradual migration back into freshwater areas where spawning is thought to occur. Most delta smelt die after spawning but a small contingent of adults survive and can spawn in their second year (Moyle 2002). Given the reported size decline and reduced proportion of age 2 delta smelt (Sweetnam 1999, Bennett 2005), management efforts aimed at increasing the proportion of age 2 delta smelt in the population could contribute to increase the resilience of this species by reducing the probability of extremely poor recruitment in any given year.

Following the listing of delta smelt as threatened, both inter-annual trend of declining size (Sweetnam 1999, Bennett 2005) and viability (Bennett 2005) were reported. Bennett (2011) provided supporting evidence suggesting that export pumping operation in spring may entrain larval offspring of the largest and healthiest early-spawning individuals, thus, contributing to an effective source of artificial selection. Life stage population models suggest that population growth rates are mostly influenced by factors operating between juvenile and pre-adult life stages, or otherwise, during the summer months with growth-associated recruitment failure as the most likely process affecting the delta smelt population. In late summer, when juveniles are most abundant, suitable habitat is decreasing and competition with other planktivorous fishes is increasing. This is believed to reduce the proportion of juveniles surviving to the adult stage (Nobriga et al. 2008).

The extent of late-summer and fall abiotic habitat for juvenile and pre-spawning delta smelt appears to influence survival to adulthood. In recent years the extent of abiotic habitat has been constricted due to consistently upstream placement of X2 caused by reduced Delta outflow related to hydrology and water project operations (Figure 3). Reduced Delta water outflow causes X2 to move upstream, which seems to concentrate delta smelt in a smaller area along with other competing planktivorous fishes (Bennett 2005). Causes of such reduced outflows include smaller upstream releases from dams, increased water exports from the State and Federal facilities, and upstream water diversions for flooding rice fields (Feyrer et al. 2007, USFWS 2008).

Delta smelt are also believed to require relatively turbid (not clear) waters to capture prey and avoid predators (Feyrer et al. 2007). Increased water clarity during the summer and fall has been shown to be negatively correlated with subsequent summer delta smelt abundance indices (Feyrer et al. 2007, Nobriga et al. 2008).

The annual upstream spawning migration of adult delta smelt appears to be triggered by initial winter flow pulses and associated increases in turbidity. The geographical distribution of spawning adults, and thus their CVP/SWP export facility entrainment risk, is influenced by turbidity in the central and southern Delta. In particular, high levels of turbidity in Old and Middle rivers, in combination with strong water export-related reverse flows, can result in high levels of CVP/SWP entrainment.

At least three species of non-native fish with the potential to prey on delta smelt occur within the Delta: striped bass (*Morone saxatilis*), largemouth bass (*Micropterus salmoides*), and inland silversides (*Menidia beryllina*) (Bennett 2005, Baxter et al. 2008). In addition, many native and non-native aquatic species have been found to prey on delta smelt larvae and eggs. The overbite clam (*Corbula amurensis*) is a non-native species that became abundant in the Delta in the late 1980s. Starting in about 1987 to 1988, declines were observed in the abundance of phytoplankton (Alpine and Cloern 1992) and the copepod *Eurytemora affinis.* These declines have been attributed to grazing by the overbite clam (Kimmerer et al. 1994) because the overbite clam also consumes copepod larvae as it feeds (Kimmerer et al. 1994), it not only reduces phytoplankton biomass but also competes directly with delta smelt for food. *L. tetraspina* is now the most abundant copepod species in the low salinity zone (Bouley and Kimmerer 2006), and is likely an inferior prey species for delta smelt because of its smaller size and superior predator avoidance abilities when compared to *P. forbesi* (Bennett 2005, Baxter et al. 2008).

Kuivila and Moon (2004) found that peak densities of larval and juvenile delta smelt sometimes coincided in time and space with elevated concentrations of dissolved pesticides in the spring. These periods of co-occurrence lasted for up to 2 to 3 weeks.

Concentrations of individual pesticides were low and much less than would be expected to cause acute mortality; however, the effects of exposure to the complex mixtures of pesticides are unknown.

On April 7, 2010, the USFWS found that reclassifying the delta smelt from a threatened to endangered species is warranted, but precluded by other higher priority listing actions. USFWS found continuing primary threats to the species include: 1) direct entrainments by State and Federal water export facilities; 2) summer and fall increases in salinity and water clarity, and 3) effects from introduced species. Additional threats included 4) predation, 5) entrainment into power plants, 6) contaminants and 7) a small population size.

Conservation actions will enhance, and restore delta smelt habitats. Efforts will include enhancing shallow water habitat; improving food availability, providing suitable water quality and outflows; protection of and access to sufficient spawning substrate; minimizing adverse effects of water diversions; protecting critical rearing habitat from high salinity (>2 ppt) and high concentrations of pollutants.

Longfin Smelt. Longfin smelt (*Spirinchus thaleichthys*) are small native fish that live in the brackish waters of the San Francisco Bay and the Delta. In the Bay-Delta estuary longfin smelt is anadromous. Adults (fish approaching their second year of age) migrate in winter from saltwater portions of the Bay and open coast to spawn in freshwater portions of the upper Bay and Delta. Since they spawn primarily as age 2 fish, they tend to maintain strong even-year or odd-year cohorts, depending upon the sequence of wet and dry years. Longfin smelt abundance has a strong relationship to X2 (Figure 2).

Longfin smelt were extremely abundant in the estuary when the fall midwater trawling program began in the 1960's. Evidence suggests that longfin smelt populations in the 19^{th} century were abundant enough to support a fishery. Major factors limiting this species include low Delta outflow, poor food web productivity, effects of water diversions, poor dispersal of larvae, and potentially higher concentrations of toxins.

On April 2, 2012, the USFWS found that listing the Bay-Delta distinct population segment (DPS) of the longfin smelt as threatened or endangered is warranted; however, precluded by higher priority actions at this time. USFWS found the primary threat to the Bay-Delta Longfin DPS is from: 1) reduced freshwater flows in the estuary. Additional threats include: 2) the invasion of the non-native overbite clam, 3) reductions in food availability, and 4) increase in abundance of ammonium concentrations in the estuary.

Conservation actions will include coordination of protection, enhancement, and restoration of occupied longfin smelt habitats with other federal, state, and regional programs. These efforts will include improved winter flows during drought periods; during spawning provide sufficient outflows, unrestricted access and protection of suitable habitat, and minimize adverse effects of diversions; mobilize organic carbon to improve food supplies; and protect critical rearing habitat from high salinity (>2 ppt) and high concentration of pollutants from the beginning of February to the end of August.

Chinook Salmon. Much of what has been learned about the four runs of Chinook salmon (*Oncorhynchus tshawytscha*) (winter, spring, fall, and late-fall), as well as steelhead, is the result of genetic research and management programs that occurred in upstream areas and at hatcheries. Within the Delta, ERP funded projects studied the migration and movement of adult and juvenile Chinook salmon. Findings include:

- Some tagged adult fall-run Chinook appeared to roam the Delta before committing to one river system. Behavior was highly individualistic, resulting in variable migration times and distances traveled. Most salmon tagged on the San Joaquin River exited the Delta on the Sacramento River, indicating that they may be using the Delta Cross Channel and Georgiana Slough to cross over to the Sacramento River.

- Radio telemetry was used to analyze the migratory behavior of juvenile salmonids, and demonstrated that the fish utilize the middle portions of the channels during migration, and that the fish move with the flood tide and then migrate on ebb tides.

- Acoustic studies of emigrating San Joaquin drainage juvenile salmon conducted as part of the Vernalis Adaptive Management Program (VAMP) have indicated generally low levels of survival through the southern Delta.

Conservation actions will protect, enhance, and restore occupied and historic Central Valley salmon ESU habitats with other federal, state, and regional programs. These efforts will include implementation of measures in the restoration plan for the Anadromous Fish Restoration Program, the Central Valley Salmon and Steelhead Recovery Plan and applicable CDFW management measures; appropriate operation of hatcheries such that natural populations are not threatened; management of fish passage to reduce predation on juveniles and increase their survival; improved export flows to improve conditions for upstream migration of adults; operation of physical barriers consistent with achieving recovery goals; and the determination of causes and implementation of actions to address low outmigration survival of fish from the San Joaquin River in the south Delta.

Steelhead. *Oncorhynchus mykiss*, rainbow trout, generally have one of two distinct life patterns: resident inland trout and sea-run or anadromous steelhead. Some inland trout do migrate for the purpose of spawning or food foraging. Resident forms of *O. mykiss* often spend their entire lives within a few hundred meters of stream or within the same lake. Steelhead or sea-run trout hatch in freshwater and then migrate to the ocean, finally returning home to spawn (UC California 2012).

Steelhead are somewhat unique in that they depend on essentially all habitats of a river system. They use the estuary for rearing and adapting to saltwater and the main river channel for migrating between the ocean and upstream spawning and rearing areas, and use the tributaries for spawning and rearing. As a result, they are found in virtually all of the Focus Area.

Before extensive habitat modification in the 19th and 20th centuries, *O. mykiss* were broadly distributed throughout the Sacramento and San Joaquin drainages. Historical steelhead run size is difficult to estimate given the paucity of data, but may have approached one to two million adults annually. By the early 1960s, run size had declined to about 40,000 adults. The decline continued to 10,000 fish in the 1990's (McEwan 2001). Recent numbers have continued this decline, especially in the San Joaquin River Basin (NMFS 2009b). A crude extrapolation from the incidental catch of out-migrating juvenile steelhead (captured in a midwater-trawl sampling program for juvenile Chinook salmon below the confluence of the Sacramento and San Joaquin rivers) estimated that, on average during 1998–2000, approximately 181,000 juvenile steelhead were naturally produced each year in the Central Valley by approximately 3,600 spawning female steelhead.

The primary limiting factor to steelhead in the Focus Area is the inaccessibility of more than 95 percent of its historical spawning and rearing habitat due to impassable dams (NMFS 2009b). Little information is available regarding the viability of the naturally spawning component of the population. The remaining habitat below the rim dams is subject to habitat degradation and various impacts from water development activities and land use activities. The lack of adequate status and trend monitoring and research limits our understanding of the viability of this fish and our ability to determine how steelhead populations may have interacted before the dams were built (Lindley et al. 2007). In addition, the geographically wide stocking of hatchery fish may have had deleterious effects on native wild trout populations, but this has not been adequately assessed. It is likely many of the threats affecting Chinook salmon, such as inadequately screened water diversions; excessively high water temperatures, and predation by non-native fish species, are also negatively impacting steelhead.

Although the apparent dominance of resident form of steelhead is a recent and unnatural shift in life history strategy, Lindley et al. (2009) noted that the effect of residents on the viability of Central Valley populations is unknown and could actually reduce the extinction risk through the production of anadromous individuals that can bolster or rescue weak steelhead populations. More information on the impact of the resident form on the anadromous population should be developed in order to protect this species.

Conservation actions will include coordination of protection, enhancement, and restoration of occupied and historic Central Valley steelhead habitats with other federal, state, and regional programs; implementation of measures in the restoration plan for the Anadromous Fish Restoration Program (AFRP), the Central Valley Salmon and Steelhead Recovery Plan and applicable CDFW management measures; and the minimization of flow fluctuations to reduce or avoid stranding of juveniles.

Green and White Sturgeon. Sturgeons are important native anadromous sport fish with high recreational and ecological value. They inhabit both salt water and freshwater, tolerate a wide range of salinity concentrations and spawning occurs in larger rivers upstream of the Delta. Much of what has been learned about green and white sturgeon is the result of studies and activity that occurred in areas upstream of the Delta Region. Change in abundance of older fish may reflect the harvest of adults and habitat conditions that occurred decades ago during the larval and early juvenile life stages.

White sturgeon (*Acipenser transmontanus*) are native to Central Valley rivers and the Bay-Delta and represents an important component of the historic native fish fauna. They support a valuable sport fishery in the Bay and Delta. White sturgeon rear in the Sacramento-San Joaquin estuary and spawn in the Sacramento and San Joaquin rivers and their major tributaries. Monitoring of white sturgeon by CDFW continues to indicate that strong year classes are produced only in years of high spring outflow, with 2006 being the most recent strong class.

Green sturgeon (*Acipenser medirostris*) are an at-risk species native to the Sacramento River. Little is known about the habitat needs of this species and its responses to restoration. Spawning has been confirmed only in the Sacramento and Klamath rivers in California (Moyle et al. 1995). Adult and juvenile green sturgeons have been reported only in San Francisco Bay (Aplin 1967 in Wang 1986), San Pablo Bay (Miller 1972 in Wang 1986), and the lower San Joaquin River and the Delta (Radtke 1966 in Wang 1986).

Within the Delta, ERP funded projects studied the effects of selenium on the health and reproduction of white sturgeon. Some findings include:

- High variation in selenium levels could be linked to seasonality, and specifically the seasonal presence of overbite clam in the Delta and Suisun Bay.
- Microinjection of over 15 milligrams per gram of selenium in white sturgeon larvae significantly increased mortality and abnormality rates (including edema and spinal deformities).

Conservation efforts will focus on major limiting factors to sturgeon populations, such as inadequate streamflows to attract adults to spawning areas, illegal harvest, and entrainment into water diversions. In addition, food availability, toxic substances, and competition and predation are other factors that influence sturgeon abundance that will be evaluated.

Splittail. The Sacramento splittail (*Pogonichthys macrolepidotus*) is a native resident fish of the lower reaches of the Sacramento and San Joaquin rivers and the Bay-Delta Estuary. Once widespread in lowland waters of the Central Valley, today splittail are largely confined to the estuary, except during wet years. The species tolerates a wide range of salinity, but is most abundant in shallow areas where salinity is less than 10 parts per thousand. The splittail population dropped to a low point in the estuary during the drought of the 1980s but rebounded to high levels in the estuary during wet years of the 1990s.

Splittail are facultative floodplain spawners and will use streamside vegetation. Year-class abundance varies greatly, but is generally associated with winter and spring flows sufficient to flood peripheral areas of the Delta and lower river reaches and flood bypasses of the Sacramento and San Joaquin rivers during very wet years. Splittail have a high fecundity which, when combined with years of high flows, allows the population to benefit from high recruitment rates.

Loss and degradation of shallow, near-shore habitat is a historic, current and future threat to the splittail. Riparian and natural bank habitats are features that historically provided splittail with spawning substrate, organic material, food supply, and cover from predators. Vast stretches of the Sacramento and San Joaquin Rivers, their tributaries, and distributary sloughs in the Delta have been channelized and much of the shallow nearshore habitat has been leveed and riprapped. The prevention of channel meandering by the placement of riprap is causing a continual loss of low velocity shallow water breeding habitat (Feyrer et. al*.* 2005).

Although recent research has shed some light on the dynamics and impacts of contaminants entering the Delta system, the overall effects of these contaminants on ecosystem restoration and species health are still poorly understood. All major rivers that are tributaries to the estuary are exposed to large volumes of agricultural and industrial chemicals that are applied in the Central Valley watershed (Nichols et al. 1986), as well as chemicals originating in urban runoff that find their way into the rivers and estuary. In addition, reflooding of the Sutter and Yolo Bypasses and the use of other flooded agricultural lands by splittail for spawning can result in agricultural-related chemical exposures. The recent increased reliance of splittail on overbite clams as a food source may be a risk factor for increased selenium accumulation in splittail. Sommer et al. (1997) showed that the year class strength of splittail is highly correlated with the duration of spring flooding in the Sacramento River system. Optimal conditions include a period of inundation of terrestrial vegetation on the floodplain between March and May sufficient to give adults time to improve their condition by feeding before spawning, three to five days for the eggs to hatch, and then continued floodplain inundation for optimal rearing conditions for larval fish and juveniles (Moyle et al. 2004). With this work and subsequent work (Feyrer et al. 2006, Sommer et al. 2008) it has been shown that seasonal floodplains are critical for splittail reproduction and must be considered part of their management strategy. Inundation of floodplains also provides this access to large areas of shallow, vegetated habitat for post-spawning recovery of adults, and rearing of juveniles (Sommer et al. 2008). An additional benefit of the seasonally inundated habitat is the high levels of invertebrate prey (Sommer et al. 2001a, Sommer et al. 2004). Feyrer et al. (2007) has demonstrated that young splittail grow better in floodplains. They also have shown that the manner in which floodplain connectivity is established and the underlying physical habitat of the floodplain area are both important in structuring fish communities. Floodplain restoration and reconnection provides a way to increase total habitat availability for splittail and other species such as

Chinook salmon (Sommer et al. 2008, SJRRP 2009). These studies also found that not all types of wetlands are favorable for splittail. For example, permanent wetlands may not support high production of native fishes, because they become dominated by non-native competitors and predators (Feyrer et al. 2004, Moyle et al. 2007).

On October 7, 2010, the USFWS found that listing the Sacramento splittail as endangered or threatened under the ESA was not warranted at that time due to the following: 1) there is presently sufficient habitat to maintain the species, and 2) inundation frequency, and duration in key areas is sufficient to provide spawning to maintain the species.

Conservation for splittail will coordinate protection, enhancement, and restoration of occupied and historic splittail habitats with other, federal, state, and regional programs. These actions will remove diversion dams that block access to lower floodplain river spawning areas, design seasonal wetlands hydrologically connected to channels, change timing and volume of freshwater flows, improve Delta water facility operations and water quality, screen unscreened Delta diversions, manage harvest activities, set back levees to increase shallow water habitat, and reduce the extent of reversed flows in the lower San Joaquin River and Delta during February through June.

Lamprey. Lampreys are jawless eel like fishes and are the most primitive of all fishes residing in California waters. These species have a round sucker-like mouth (oral disc), no scales, and breathing holes instead of gills. Most lamprey species have a similar life cycle: all begin life in freshwater, but some are anadromous. In the beginning of their life cycle, the lamprey eggs hatch and the young ammocoetes (larvae) drift downstream to areas of low velocity and silt or sand substrate. They remain burrowed in the stream bottom, filter-feeding on algae and detritus (Kostow 2002, Moyle 2002). Three lamprey species occur in the Sacramento-San Joaquin system: Pacific lamprey and river lamprey, both predatory and western brook lamprey which is non-predatory.

The Pacific lamprey (*Entosphenus tridentatus)* is an anadromous fish that spends its predatory phase in the ocean. After spending up to three years in the ocean, adults return to fresh water to spawn. Migration occurs between April and late-July, with adults moving upstream several months prior to spawning. After spawning, the adults die and the eggs settle and adhere to the substrate. The juveniles begin the transformation into adults between 140 mm and 160 mm and migrate to the ocean as sexually immature juveniles known as macropthalmia, where they will grow and mature.

The river lamprey (*Lampetra ayresi*) is an anadromous fish that is predaceous on fish in both salt and freshwaters. Adults migrate from the ocean and move into smaller tributary streams in April and May to spawn, and die shortly afterwards. After the eggs hatch, the larvae remain in fresh water from 4-7 years until they reach approximately 117 mm in length, when they will undergo metamorphosis and then migrate as macropthalmia to the ocean.

The western brook lamprey (*Lampetra richardsoni*) is a relatively small nonpredaceous fish that resides in the Sacramento and San Joaquin rivers and their tributaries. They remain in fresh water, not feeding as adults, resulting in a short life span (Wydoski and Whitney 2003). However, western brook lampreys are not anadromous and thus are not subject to threats associated with ocean conditions, including loss of estuarine habitat, and barriers to and from ocean environments which are threats experienced by Pacific lampreys and river lampreys.

The health of these populations is adversely affected by many activities including: urbanization, agricultural practices, livestock grazing, dairy farming, timber harvesting, gravel mining, water development, summer dams, urban runoff, water discharge, passage at road culverts, dredging, streambed scouring, pollution, flood control and ocean conditions. Access to spawning grounds has been blocked due to dams on the Sacramento and San Joaquin rivers and their tributaries. Like any native species, the lamprey is an indicator of ecological health. The decline of the lampreys is presumably due to the decline of the salmonids, their major prey species, deterioration of their spawning and rearing habitat, entrainment in diversions, the heavy use of alevins for bait, and the above factors affecting fish health in the system.

Conservation actions will align with the existing Pacific Lamprey Conservation Initiative (PLCI), a USFWS strategy to improve the status of Pacific lampreys by proactively engaging in a concerted conservation effort. The resulting collaborative conservation effort, including the State of California, will facilitate opportunities to address threats, restore habitat, increase our knowledge of Pacific lamprey, and improve their distribution and abundance. The PLCI seeks to improve the status of Pacific lamprey by coordinating conservation efforts among states, tribes, federal agencies, and other involved parties.

Sacramento Perch. Sacramento perch (*Archoplites interruptus*) populations have declined throughout their native range; only two small populations remain. Possible reasons for the Sacramento perch's decline include loss of habitat, competition with non-native species, and egg predation (USFWS 1995a). Sacramento perch, the only native sunfish found in California, was originally widely distributed in the Sacramento, San Joaquin, Pajaro, and Salinas rivers and in Clear Lake.

Within its native range, a small population of Sacramento perch remains in Alameda Creek and in Clear Lake. In addition, Sacramento perch is found in scattered locations in California and Nevada, mainly in farm ponds and reservoirs into which it has been introduced, including San Luis Reservoir, Clear Lake Reservoir, Crowley Lake, Lake Almanor, Blue Lake, and Pyramid Lake. Introduced populations are also present in the Russian River, the lower Walker River, and the Owens River. Almost all recently established populations were derived from the Brickyard Pond in Sacramento, where they are currently extirpated (USFWS 1995a, Moyle et al. 2002).

Historically, Sacramento perch inhabited sloughs, sluggish rivers, marshes, and lakes of the Central Valley floor. Beds of rooted and emergent aquatic vegetation provided spawning and early-rearing habitat. Sacramento perch are tolerant of high salinity, temperature, and turbidity. Female Sacramento perch spawn during their second or third year of life. Several thousand eggs are laid over a nest near vegetation during spring and early summer at water temperatures between 61.8°F and 84.2°F (16.5ºC and 29ºC). Larvae and juveniles rear among aquatic plants. Relative to other sunfish, Sacramento perch grow fast on a diet of invertebrates and fish. They may live up to 9 years (USFWS 1995a).

Loss and degradation of floodplain and marsh habitat have been major contributors to the decline of Sacramento perch in the Central Valley. Land reclamation, flood control practices, and agricultural development have eliminated and drastically altered much of the ephemeral and perennial shallow-water habitats in the lowland areas available to spawning adults, larvae, and juveniles. Predation by and competition with introduced species have also contributed to a decline of this species. Introduced catfish, minnows, and sunfish feed on the eggs, larvae, and juveniles of Sacramento perch. Introduced sunfish also compete for nest sites and rearing areas. The combined effect of habitat loss and high abundance of introduced predators and competitors have most likely extirpated the Sacramento perch from its historical range (USFWS 1995a).

Experimental introductions of Sacramento perch into the Delta ecosystem would increase the number of populations within its native range (i.e., introducing two populations would double the number of populations in its native range). Populations could be established in flooded Delta islands where competitors are not present, then spread to surrounding areas through flooding as the populations became larger (USFWS 1995a, Moyle et al. 2002).

Other At-Risk Species. While many of the ERP activities in the Delta and its watershed focus on fish and aquatic resources, the ERP also provides funding to numerous studies, land acquisitions, and habitat creation efforts designed to benefit terrestrial species and plant communities. These other species were specifically identified in ERPP and MSCS documents and their associated descriptions, actions, targets and desired outcomes in those documents are incorporated by reference in this document. Some of the ERP's findings and activities associated with these species include:

- Genetic studies on the western pond turtle, foothill yellow-legged frog, California tiger salamander, and western spadefoot toad yielded information on distinct lineages and management units and gave recommendations on how the different populations should be managed.
- A study on the yellow warbler, common yellowthroat, black-headed grosbeak, and tricolored blackbird found little evidence of fine-scale population structure or isolated populations, and recommended that each species be managed as a single unit. In addition, observations suggest that there are two distinct populations of tricolored blackbird that might be separate subspecies.
- Acquisition of fee or easement title of lands along the Stanislaus and San Joaquin rivers, and restoration of riparian and floodplain habitat for riparian brush rabbits and riparian woodrats.

- Acquisition and management of a 320-acre site in Yolo County supporting alkali vernal pools including Crampton's tuctoria, Colusa grass, alkali milk-vetch, and several other rare plants, animals, and vernal pool species. The grass-dominated upland areas provide foraging habitat for Swainson's hawk and western burrowing owl.

The following provides a focused list of other at risk species but should in no way be construed to limit ERP's conservation focus to a level different than that identified in the earlier ERPP and MSCS documents.

Black Rail. Historically, the black rail (*Laterallus jamaicensis coturniculus*), a State of California threatened and fully-protected species, occurred in saline and brackish emergent wetlands in the San Francisco Bay, coastal Marin County, coastal wetlands of southern California, and isolated interior areas of southern California (Grinnell and Miller 1944). In 1992, the distribution of the California black rail was thought to be restricted to a few areas including the San Francisco Estuary, and a small number of occurrences in the Delta (DFG 1992). In the estuary, the vegetation in the more saline wetlands is generally dominated by pickleweed, salt grass, and tule, all of which are used for nesting. Evens et al. (1991) found that California black rail occurred almost exclusively in marshlands with unrestricted tidal influence; few birds were associated with diked, impounded, or partially tidal marshes. More recently California black rails have been found in 164 small, widely scattered marshes distributed along the lower western slopes of the Sierra Nevada foothills from just northeast of Chico (Butte County) to Rocklin (Placer County) (Richmond et al. 2008). Surveys conducted for the BDCP in 2009 and 2010 detected California black rails on many instream islands with mixed willow/dogwood and tule vegetation. Creation of habitat for the black rail is being considered in restoration plans and floodplain acquisitions in the Delta.

Greater Sandhill Crane. The greater sandhill crane (*Grus Canadensis tabida*) is found throughout most of the Central Valley in winter and nests in northeastern California and Oregon. Habitats used include seasonal and fresh emergent wetlands, grasslands, and agricultural lands. Large wintering populations of greater and lesser sandhill cranes congregate in the Sacramento and San Joaquin Valleys. Much of their nesting habitat has been lost due to conversion to agricultural lands and intensive cattle grazing. These birds forage in moist cropland such as flooded pasture and irrigated alfalfa, as well as in emergent wetlands, fallow fields, uncultivated areas, canals, and irrigation ditch banks. They prefer open areas with shallow fresh water for drinking and bathing. The loss of habitat and decline in condition of the subspecies population has warranted its listing as threatened under the California Endangered Species Act. Major factors contributing to the decline of the species include loss of grassland and wetland habitats and nest predation.

Conservation efforts will include implementation of actions in concert with species recovery strategies, including the enhancement of agricultural habitat to improve the abundance and availability of upland agricultural forage (e.g., corn and winter wheat). The restoration of wetlands should give priority to restoring and managing wetland habitat within areas that provide suitable roosting habitat and recreational uses should be avoided or minimized in areas that could disrupt crane habitat use patterns from October-March. A portion of enhanced agricultural lands should be managed to increase forage abundance and availability for cranes and monitoring efforts to determine their use of protected, restored and enhanced habitats in core wintering areas should be completed.

***Tricolored Blackbird*.** The Tricolored Blackbird (*Agelaius tricolor)* is North America's most colonial landbird. Its breeding colonies often teem with more than 50,000 birds, sometimes all settled into a single 10-acre field or wetland to raise their young.

In the 19th Century, Tricolored Blackbird flocks were described as so numerous "as to darken the sky." Since then, the population has declined from several million to slightly less than 300,000 today. Over just the last 70 years, the Tricolored Blackbird population has decreased by more than 80%. The reasons for this decline are many, but the loss of marsh and nearby foraging habitats along the coast and in the Central Valley is the main cause. In more recent years, the species has become dependent on agricultural lands, with most of the largest colonies nesting in grain fields. A real dilemma develops because Tricolored young typically have not yet left the nest before the time farmers harvest their crop, and harvesting destroys Tricolored Blackbird nests and young. In some cases as many as 20,000 nests have been lost in a single field.

Conservation efforts include habitat conservation, research to more thoroughly understand the species' life history, monitoring to document population trends and distribution, and education to enhance public and private landowner awareness and support for conservation efforts.

***Waterfowl*.** California has lost more than 95% of its historic wetlands, largely due to urbanization, flood control and agriculture. As a result, many species have declined from historic levels, and are increasingly dependent on fewer wetlands. Despite these tremendous habitat losses, the Central Valley of California is the most important waterfowl wintering area in the Pacific Flyway, supporting up to 60% of the total Flyway population in some years (Heitmeyer 1989) and higher proportions of certain populations. Food availability is a key factor limiting waterfowl populations during migration and winter (Miller 1986, Conroy et al. 1989, Reinecke et al. 1989), and habitat conditions on the wintering grounds may influence reproductive success (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987, Raveling and Heitmeyer 1989).

ERP supports action to maintain and restore healthy populations of waterfowl at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Conservation actions will include improved seasonal wetlands and floodplain/stream interactions.

Neotropical Migratory Birds. Neotropical migratory birds breed in Canada and the United States during our summer and spend our winter in Mexico, Central America, South America or the Caribbean islands. The majority are songbirds (such as warblers, thrushes, tanagers, and vireos), but there are also many shorebirds (such as sandpipers, plovers, and terns), some raptors (such as hawks, kites and vultures), and a few types of waterfowl (such as teal). Conservation of neotropical migratory birds focuses on protection of populations; maintenance, management, protection, and restoration of appropriate habitats; research and monitoring; law enforcement; and education. The following are examples of neotropical migratory birds included in this strategy.

***Bank Swallow*.** The bank swallow (*Riparia riparia*) has been recorded in the lowlands of California since ornithologists began exploration in the midnineteenth century (Grinnell and Miller 1944). Newberry (1857) considered the species to be common throughout California. Today, bank swallows are locally common only in certain restricted portions of their historic range where sandy, vertical bluffs or riverbanks are available for these colonial birds to construct their nest burrows. The bank swallow nests in earthen banks and bluffs, as well as sand and gravel pits. It is primarily a riparian species throughout its North American and Eurasian breeding range.

Once locally abundant in suitable habitats, a CDFW study of the statewide population of Bank Swallows in 1987 found that the current population center for the species is along the Sacramento and Feather rivers in the Sacramento Valley. This region supports an estimated 70 percent of the statewide population. One of the primary reasons for decline of this species is loss of habitat. State and Federal sponsored and funded bank protection projects have resulted in the rip-rapping of several miles of naturally eroding riverbank that the Bank Swallows depend on for nesting. The primary objectives necessary to recover the species include: 1) ensure the remaining population does not suffer further declines in either range or abundance, and 2) provide for the preservation of sufficient natural habitat to maintain a viable wild population in perpetuity.

Conservation will coordinate protect and restore channel meander belts and existing bank swallow colonies with other federal and state programs (e.g., participation in planning and implementation of activities associated with the Army Corps of Engineers' Sacramento and San Joaquin Basin levee efforts and The Riparian Habitat Joint Venture) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. Proposed ERP actions designed to protect or restore stream meander belts should initially be implemented along reaches of the Sacramento River and its tributaries that support nesting colonies or potential nesting habitat. Monitor to determine the response of bank swallows to restoration of stream meander belts and riparian habitat. Coordinate with Reclamation and DWR to phase spring-summer reservoir releases in a manner that would reduce the potential for adverse effects on nesting colonies that could result from large, pulsed, releases.

California Yellow Warbler. The California yellow warbler (*Dendroica petechia*) summers throughout northern California and in the coastal regions of southern California. During these months the California yellow warblers utilizes underbrush of open deciduous riparian woodland for home territories, foraging areas, and nesting. In recent decades, there has been a marked decline in the breeding population of these birds in both the San Joaquin and Sacramento valleys. Loss of riparian habitat from agricultural and urban development, and brood parasitism by brown-headed cowbirds are believed to contribute to the decline of this species.

Riparian vegetation and the physical processes that maintain its development are critical for supporting populations of the riparian-associated California yellow warbler (RHJV 2000). The California yellow warbler is seasonally dependent on floodplain riparian habitats for foraging substrate, nest sites, and cover from predators. California yellow warbler uses early-successional riparian habitat for breeding (RHJV 2000). Levees and flow regulation limit the development of the shrubby riparian habitat required by this species. The complex vegetation mosaic that results from meandering rivers and streams sustains habitat for California yellow warbler populations.

Conservation efforts include coordination of protection and restoration of riparian habitat with other federal and state programs that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. As possible, protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat. A portion of restored riparian habitat area should be designed to include riparian scrub communities. Associated with implementing ERP's wildlife friendly agriculture program, work with farmers to reestablish native trees, shrubs, grasses and wildflowers on their field edges. As practicable, restoration of riparian habitats should be in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

Least Bell's Vireo. The Least Bell's vireo (*Vireo bellii pusillus*) is the westernmost of four subspecies of Bell's Vireo. Its historical breeding habitat was from the northern end of the Central Valley to Baja California in Mexico. The San Joaquin Valley was the historical center of its breeding range. The species was common to locally abundant in lowland riparian forests of the San Joaquin River (Franzreb 1989). Some Sierra Nevada and Coast Range streams also had historical populations. Due to its depleted population in remaining habitat, the California Fish and Game Commission listed it as Endangered in 1980. At the time of its listing by the USFWS in 1986, it had been extirpated from most of its historical range, including the entire San Joaquin Valley, and numbered just 300 pairs statewide, confined mostly to eight counties south of Santa Barbara. Since listing, Least Bell's Vireo numbers have increased 6-fold, and the species is expanding into its historical range. In 1989, the population size was estimated at 2,000 pairs (Franzreb 1989).

In June of 2005, a Least Bell's Vireo nest was located in an ERP-sponsored riparian restoration site at the San Joaquin River National Wildlife Refuge. A pair returned to the refuge in 2006 and successfully bred, although this was followed by an unsuccessful attempt by an unpaired female in 2007 (Howell 2010). This illustrates the possibility for reestablishment of Least Bell's Vireo as the ERP continues to work towards recovery of the San Joaquin River ecosystem.

Conservation efforts will continue to coordinate protection and restoration of riparian habitat with other federal and state that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. As possible, actions will protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat. A portion of restored riparian habitat area will be designed to include riparian scrub communities and, associated with implementing ERP’s wildlife friendly agriculture program, work with farmers to reestablish native trees, shrubs, grasses and wildflowers on their field edges. As practicable, restoration of riparian habitats will be in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

Swainson's Hawk. Swainson’s hawks (*Buteo swainsoni*) are a Federal Species of Concern in some regions and are listed as a California threatened species. This hawk is a large, highly migratory raptor with a breeding distribution that extends across grasslands, open woodlands, and today incorporates many agricultural landscapes of western North America (Hull et al. 2007). In the Central Valley, the Swainson’s hawk most frequently nests in single trees or in riparian vegetation adjacent to foraging habitat, which is usually agricultural land (Estep 1989, CALFED 2000a). While this species nests in the riparian areas, it forages in upland grassland and croplands.

Swainson’s hawks were historically considered to be one of the most abundant raptor species in western North America, but have declined precipitously in many parts of their range during the 20th century. Declines began during European settlement with many regions experiencing marked declines by 1900. During the 20th century within the Central Valley and the rest of California, the range of this species was reduced dramatically (England et al. 1997).

Concomitant with the decrease in range was a 90 percent decline in Swainson’s hawk numbers (Bloom 1980). Historical populations were estimated between 4,000 and 17,000 pairs, but declines were documented as early as 1940. In 1979, 110 active pairs were observed in the Central Valley. Anderson et al. (2007 unpublished) completed a survey of the current breeding range of the Swainson’s hawk using a stratified random survey design. Anderson’s state-wide estimate for the number of breeding pairs is 2081 (95% CI: 1770-2393). A more recent CDFW survey of nesting Swainson’s hawk was conducted in a portion of the Central Valley (Butte to San Joaquin counties) during the period 2002-2009. The later survey yielded a population estimate of between 593 and 1008 breeding pairs for the Central Valley north of the Stanislaus River. Today, the few remaining concentrations of breeding pairs are supported within the Yolo, Sacramento, San Joaquin, Sutter, and Colusa counties.

Extant populations within California include portions of the Central Valley, the Modoc Plateau in northeastern California, and a remnant population in Owen’s Valley and the

Mojave Desert. This hawk has been extirpated from coastal southern California and the coastal foothills and plains (Bloom 1980, Hull et al. 2007).

Hull et al. (2007) did not find that the Central Valley population is evolutionarily distinct, though they did find some genetic separation from the Great Basin populations. They also reported that based on published literature and through personal communications, the Central Valley does have an established winter population whereas the Great Basin population does not. This over-wintering behavior, along with the use of coastal western Mexico as wintering range for the rest of the Central Valley population, could ultimately contribute to nascent divergence in Swainson's hawks and may reflect an ecological response to changing environmental conditions, local agriculture practices or climatic changes (Hull et al. 2007).

While the genetic data are somewhat ambiguous relative to distinct population segments, differences between the populations in the Central Valley and the Great Basin traits, along with their historically precipitous decline in California call for careful conservation, management, and monitoring of Swainson's hawks of the Central Valley.

The Swainson's hawk usually returns to the same nest site, so preservation of current nest sites is important for the species conservation. Loss and degradation of nesting habitat, along with other factors such as high rates of mortality during migration and in South American wintering areas and reduced reproductive success because of pesticide effects on eggshells, are cited as reasons for the Swainson's hawk's decline (CALFED 2000a). Pesticide poisonings in wintering ranges can result in mass mortalities (England et al. 1997, Hull et al. 2007). However, Sarasola et al. (2008) found that the lack of connectivity between populations of breeding and wintering hawks suggests that high wintering mortality, either natural or human-induced, is unlikely to have direct consequences on a single breeding area in North America

Conservation actions will focus on the restoration of valley/foothill riparian habitat initially in the Delta. Seasonal wetlands will be designed into occupied habitat areas to provide overwinter refuge for rodents to provide source prey populations during spring and summer. Actions will include a percentage of agricultural lands to be enhanced under the ERP in the Delta, Sacramento River, and San Joaquin River Regions to increase forage abundance and availability within 10 miles of occupied habitat areas. Efforts will manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels. As practical, actions will manage restored or enhanced habitats under the ERP to maintain desirable rodent populations and minimize potential impacts associated with rodent control.

Yellow-billed Cuckoo. In California's Central Valley, the western yellow-billed cuckoo (*Coccyzus americanus*) depends on riparian vegetation for cover, foraging, and breeding (RHJV 2000). Within riparian vegetation, dense, low, shrubby vegetation is a particularly important habitat component (Dunn and Garrett 1997, Brown 1993, RHJV 2000). In addition, landscape attributes such as patch size and surrounding land uses affect western yellow-billed cuckoo populations. Populations of western yellow-billed cuckoo persist best in large blocks of riparian forest (20–80 ha and often more than 300 ft wide) of meandering riparian zones (Halterman 1991).

Conservation efforts will continue to coordinate protection, restoration and enhancement of large, contiguous areas of riparian and wetland habitat with other federal and state programs that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. These habitat areas should maintain a great diversity in composition, density and make-up. As possible, actions will protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat. A portion of restored riparian habitat area will be designed to include riparian scrub communities and, associated with implementing ERP's wildlife friendly agriculture program, work with farmers to reestablish native trees, shrubs, grasses and wildflowers on their field edges. As practicable, restoration of riparian habitats will be in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

California Red-legged Frog. The California red-legged frog (*Rana draytonii*) is California's largest native frog. Its habitat is characterized by dense, shrubby riparian vegetation associated with deep, still, or slow-moving water that supports emergent vegetation. This species historically occurred throughout the Central Valley and now exists only in small isolated populations scattered throughout its historical range. Its current range is primarily west of the Cascade-Sierra crest from Redding to northwest Baja, California. Small populations exist in the Central Valley and Sierra Nevada, but numbers are on the decline.

Major factors for the decline of the California red-legged frog include degradation and loss of critical wetland breeding habitat and adjacent terrestrial habitats. Stressors from human activities like agricultural practices (disking, mowing, burning, and pest control) also contribute to the population decline. Restoration of suitable aquatic, wetland, and riparian habitats and reduced mortality from predators will be critical to achieving recovery of the California red-legged frog

Conservation measures will protect, restore, and enhance suitable aquatic, wetland, and riparian and upland habitats that will benefit the recovery of the red-legged frog. Efforts to manage invasive species such as the bullfrog will also be carried out where necessary to benefit the recovery of the species.

Foothill Yellow-legged Frog**.** The foothill yellow-legged frog (*Rana boylii)* has disappeared from much of its range in California (possibly up to 45 percent). Populations south of southern Monterey County are now apparently extinct. Extremely high water levels in 1969 may have been one cause for that decline. *R. boylii* is also gone from an estimated 66 percent of its range in the foothills of the Sierra Nevada Mountains, especially south of highway 80 where it is nearly extinct. Water released from reservoirs, that washes away eggs and tadpoles and forces adult frogs away from the streams leaving them more vulnerable to predators, is a serious problem for frogs in the Sierra Nevada foothills. Air-borne pesticides from the vast agricultural fields of the Central Valley are also likely to be a primary threat. Recreational activities along streams that alter streambeds, especially gold mining, are also having a negative impact on frog populations in the Sierra foothills. Introduced fish also stress frog populations by consuming eggs and tadpoles, and introduced bullfrogs compete for food and eat the frogs. Habitat loss, disease, introduced crayfish, stream alteration from dams, mining, logging, and grazing, are also threats to this frog.

Conservation measures will continue to protect, restore, and enhance suitable aquatic, wetland, riparian and upland habitats that will benefit the recovery of the species; and feasible actions will be implemented to address concerns with disease, introductions of non-native trout, airborne contaminants, wildland fires, fire suppression activities, climate change, livestock grazing, water developments, and recreational activities. Efforts to manage invasive species such as the bullfrog will also be carried out where necessary to benefit the recovery of the species.

***California Tiger Salamander*.** The California tiger salamander (*Ambystoma californiense*) uses burrows for aestivation and shelter during the warm, dry months of summer and autumn. Because California tiger salamanders dig poorly, the burrows of small mammals are essential. Their dependence upon the upland burrows of California ground squirrels and Bota’s pocket gopher is called a commensal relationship; it neither helps nor harms the burrowing mammals, but is of great benefit to the salamanders. Because the ground squirrel and pocket gopher tunnels collapse within 18 months of abandonment, the ongoing co-location with these animals is critical for the survival of California tiger salamanders that spend the majority of their life in upland habitat. This habitat is usually grassland or oak savannah, and sometimes oak woodland.

California tiger salamanders exhibit a biphasic life cycle and as a result require two distinct habitats. At the onset of the winter rains, these salamanders will emerge from their burrows to feed and migrate as far as one mile to their wetland breeding ponds. These are vernal pools or seasonal ponds within the grasslands or oak savannah, or even stock ponds that mimic seasonal ponds. In years of “normal” amounts of rainfall these ponds will retain water long enough for salamanders to complete their larval stage and metamorphose, but not long enough, as in the case of permanent ponds, to be habitable by major predators such as fish and bullfrogs. Within that range of water retention, larvae develop faster in smaller, more rapidly drying ponds. However, the longer larvae remain in the pond, the larger they will be and the more likely they are to survive and reproduce. It is estimated that during the life of an average female California tiger salamander, just 11 of her offspring will reach metamorphosis. Other estimates further suggest that only 5 percent of juveniles survive to become breeding adults.

Conservation actions will maintain existing populations in the Bay-Delta, protect and restore existing and additional suitable aquatic, wetland, and floodplain habitats and reduce the effect of other factors that can suppress breeding success.

Western Spadefoot Toad. Optimal habitat for the western spadefoot toad (*Spea hammondii*) is grasslands with shallow temporary pools. Adults of *S. hammondii* take insects, worms, and other invertebrates (Stebbins 1972). Adults of the very similar species *S. multiplicatus* were found to eat primarily butterfly and moth larvae, ants, termites and beetles (Whitaker et al. 1977, Dimmitt and Ruibal 1980). Tadpoles consume planktonic organisms and algae, but are also carnivorous (Bragg 1964) and consume dead aquatic larvae of amphibians, including their own species. *S. bombifrons* tadpoles capture and consume fairy shrimp (Bragg 1962).

Western spadefoot toads are rarely found on the surface. Most of the year is spent in underground burrows up to 0.9 m (36 in) deep (Stebbins 1972), which they construct themselves. Some individuals also use mammal burrows. Recently metamorphosed juveniles seek refuge in the immediate vicinities of breeding ponds for up to several days after transformation. They hide in drying mud cracks, under boards and other surface objects including decomposing cow dung (Weintraub 1980).

Breeding and egg laying occur almost exclusively in shallow, temporary pools formed by heavy winter rains. Egg masses are attached to plant material, or the upper surfaces of small submerged rocks (Stebbins 1951). Rainfall is important in the formation and maintenance of breeding ponds. Most surface movements by adults are associated with rains or high humidities at night. During dry periods, the moist soil inside burrows provides water for absorption through the skin (Ruibal et al. 1969, Shoemaker et al. 1969). Dispersal of post-metamorphic juveniles from breeding ponds often occurs without rainfall.

Conservation actions will maintain the species in the Bay-Delta by protecting and restoring existing and enhancing additional suitable aquatic, wetland, and floodplain habitats; and by reducing the effect of other factors that can suppress breeding success. To stabilize and increase its population, efforts will focus on the elimination of non-native predator species from historic habitat ranges. Additionally, actions will increase suitable habitat and maintain clean water supplies to meet the needs of this species.

Giant Garter Snake. The giant garter snake (*Thamnophis gigas*) inhabits Central Valley sloughs, low-gradient streams, marshes, ponds, small lakes, agricultural wetlands, and other year-round waterways, where it feeds on small fish and frogs during its active season.

Ideal habitat would be characterized by dense emergent vegetation for escape from predation, deep and shallow pools of water that persist throughout the seasonal cycle of activity to provide forage and cover opportunities, open areas along the margins for basking, and upland habitat with access to structures (mounds with burrows) suitable for hibernation and escape from flooding. ERP is currently working to assure giant garter snake habitat value and/or acreage is provided protection mechanisms in ongoing north to south water transfers and habitat modification including fallowing of agricultural cropland.

Survival of the species is likely to depend upon increasing its natural habitat through marsh restoration, combined with special protection measures on the agricultural land it currently inhabits. The distribution and population of these species has declined substantially, primarily as a result of the loss or degradation of wetlands and nearby uplands. The loss of habitat and declining condition of these species populations has warranted the listing of the giant garter snake as threatened under the State and Federal Endangered Species Acts.

Conservation actions will restore wetland and upland habitats adjacent and connected to occupied habitat. Action will restore fresh emergent wetland habitat adjacent to and connected with existing non-tidal emergent wetlands already used by giant garter snake, providing essential forage habitat and refuge from predators and frequent flood events, and creating dispersal corridors by linking habitat areas.

Western Pond Turtle. The western pond turtle (Clemmys marmorata) originally ranged from northern Baja California, Mexico, north to the Puget Sound region of Washington. They have a disjunct distribution in most of the Northwest, and some isolated populations exist in southern Washington. Pond Turtles are now rare in the Willamette Valley north of Eugene, Oregon, but abundance increases south of that city where temperatures are higher. They may be locally common in some streams, rivers and ponds in southern Oregon. A few records are reported east of the Cascade Mountains, but these may have been based on introduced individuals. They range up to 305 m (1,000 ft) in Washington, and to about 915 m (3.000 ft) in Oregon.

Western pond turtles occur in both permanent and intermittent waters, including marshes, streams, rivers, ponds, and lakes. They favor habitats with large numbers of emergent logs or boulders, where they aggregate to bask. They also bask on top of aquatic vegetation or position themselves just below the surface where water temperatures are elevated. Individuals display aggressive behavior toward one another while sunning. Western pond turtles will rapidly dive off basking sites when approached by humans, even at distances of over 50 m. Consequently, this species is often overlooked in the wild. However, it is possible to observe resident turtles by moving slowly and hiding behind shrubs and trees.

Western pond turtles seek refuge in deep water, under submerged logs and rocks, in beaver burrows and lodges, and by "swimming" into deep silt. They are extremely difficult to detect under these conditions. Turtles can be encouraged to use artificial basking substrate, or rafts, which allows for easy detection of the species in complex habitats.

Conservation action includes maintaining and expanding the abundance and distribution of *C. marmorata* by maintaining or expanding its existing populations by improving stream channel, floodplain riparian processes, and reducing predator species.

Valley Elderberry Longhorn Beetle. The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) (VELB) is a federally listed threatened species, although its status and factors limiting its populations are poorly understood. These beetles are dependent on their host plant, elderberry, to meet its life history requirements for breeding and rearing of young (USFWS 1984b). Elderberry is a species component of floodplain riparian habitats. It will sometimes occupy bushes growing in degraded habitat (e.g., levees). The maintenance and continued recruitment of elderberry required by the VELB depends largely on the physical processes that support and maintain riparian successional development. Flood management practices have contributed to a substantial decline in the availability and quality of riparian habitat used by this species and its host plant.

Conservation actions will focus on riparian restoration projects that maintain and restore connectivity among riparian habitats occupied by the valley elderberry longhorn beetle within its historical range in the Delta and along the Sacramento and San Joaquin Rivers and their major tributaries.

Vernal Pool Species. Vernal pools are seasonally flooded depressions found on ancient soils with an impermeable layer such as a hardpan, claypan, or volcanic basalt. The impermeable layer allows the pools to retain water much longer then the surrounding uplands; nonetheless, the pools are shallow enough to dry up each season. Vernal pools often fill and empty several times during the rainy season. Only plants and animals that are adapted to this cycle of wetting and drying can survive in vernal pools over time.

These specialized plants and animals are what make vernal pools unique. As winter rains fill the pools, freshwater invertebrates, crustaceans, and amphibians emerge. Vernal pool plants sprout underwater, some using special floating leaves and air-filled stems to stay afloat. Some of these plants even flower underwater. Birds arrive to feed on the vernal pool plants and animals.

In spring, flowering plants produce the brightly-colored concentric rings of flowers that vernal pools are famous for. Native bees nest in vernal pools and pollinate pool flowers. Insects and crustaceans produce cysts and eggs, and plants produce seeds that are buried in the muddy pool bottom. The mud protects cysts, eggs, and seeds from the hot, dry Central Valley summer. By late summer, amphibians have dug deep into the soils and gone dormant, waiting the next rainy season. Vernal pools have completely dried out and most of the plant and animal species have either disappeared into the soils or set seed and died. In this phase, vernal pools are really "banks" full of resting seeds, cysts, and eggs that can survive through summer, and even extended droughts, until the onset of the rains begin the life cycle anew.

A diverse array of plants and animals adapted to a waterlogged spring followed by a parched summer have evolved that thrive under these conditions. Many of these are native species endemic to vernal pools or related wetland habitat. Some are listed as examples in the table below:

Plants	Animals
Downingia (*Downingia spp.)* Goldfields *(Lasthenia sp.)* Meadow foam *(Limnathes douglasii)*. Pincushion Navarettia *(Navarretia myersii)* Tricolor Monkeyflower (*Mimulus tricolor*) Sand-spurrey *(Spergularia macrotheca)* Contra Costa Goldfields *(Lasthenia conjugens)* Succulent Owl's Clover *(Castilleja campestris ssp. Succulentus)* Alkali Milkvetch *(Astragalus tener var. tener)* Chinese Camp Brodiaea *(Brodiaea pallida)* Colusa Grass *(Neostapfia colusana* Butte County meadowfoam *(Limnanthes floccose ssp. Californica)* Slender Orcutt grass *(Orcuttia tenuis)*	Tadpole Shrimp *(Lepidurus packardii)* Conservancy Fairy Shrimp (*Branchinecta conservation*) Delta Green Ground Beetle (*Elaphrus viridis*) Longhorn Fairy Shrimp (*Branchinecta longiantenna)* Vernal Pool Fairy Shrimp *(Branchinecta lynchi*) California Linderiella (*Linderiella oocidentalis*) California Tiger Salamander (*Ambystoma californiense*) Western Spadefoot Toad (*Scaphiopus hammondii*)

Conservation actions for vernal pool species will include ERP actions directed towards protecting, enhancing, and restoring suitable vernal pool and associated grassland habitat within these species historic ranges. ERP actions will coordinate these actions with other federal and state programs to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. Conservation efforts will conduct surveys to identify suitable habitat areas and enhance and restore habitats for establishment of additional populations of vernal pool species in the Delta and its watershed, and implement species introductions to establish additional populations as appropriate. Lands will be appropriately maintained when purchased or acquired under conservation easements that are occupied by vernal pool species to maintain or increase current population levels and enhance occupied habitat areas.

SECTION 2: Sacramento Valley Region

Background

The Sacramento Valley Region encompasses much of the Sacramento River, which flows for more than 300 miles from Lake Shasta to Collinsville in the Delta, where it joins the San Joaquin River. This river provides about 80 percent of the inflow to the Delta and is the largest riverine ecosystem in the State of California. The Sacramento River provides essential habitat for the spawning, holding, and rearing requirements of many anadromous fish populations, including all runs of Chinook salmon (*Onchorynchus tshawytscha*) and steelhead (*Oncorhynchus mykiss*). The Sacramento River corridor encompasses more than 250,000 acres of natural, agricultural, and urban lands upstream of the city of Sacramento. Various irrigated crops, mostly rice, grains, alfalfa, and orchard crops, are grown on flat and gently rolling terrain adjacent to much of this area. Most of this cropland is irrigated with water diverted from the Sacramento River or its tributaries. Five National Wildlife Refuges (Sacramento, Delevan, Colusa, Sacramento River and Sutter) are either adjacent to or within five miles of the Sacramento River. There are also many refuges and wildlife areas under State, local, and private ownership/management within this zone.

Unimpaired flow from the four major rivers in the Sacramento Valley Region (Sacramento, Feather, Yuba, and American Rivers) averaged a combined 17.9 million acre feet (MAF) and ranged from 5.1 to 37.7 MAF during the period from 1906-1996. The most runoff occurs in the upper watershed of the Sacramento River above Lake Shasta and on the rivers originating on the west slope of the Sierra Nevada. These watersheds produce a combined annual average runoff ranging between 1,000 to more than 2,000 acre feet per square mile. The two major tributaries to the Sacramento River along its lower reach are the Feather River (which includes flows from the Yuba River) and the American River.

Since 1900, a number of reservoirs have been constructed in this region, including Shasta, Oroville, Trinity, and Folsom, as well as numerous smaller reservoirs. Total reservoir capacity in or affecting the Sacramento Valley Region is approximately 15 MAF. These reservoirs are operated to provide agricultural and domestic water supplies, flood control capacity, and more recently, recreation and ecological flows. Historically, wetlands covered an estimated 1,400,000 acres of the Sacramento Valley and were comprised of mostly riparian forests and semi-permanently flooded tule marshes. Approximately 170,000 acres of wetlands remain and are dominated by tule marsh. Some 500,000 acres of riparian forest historically fringed the entire length of the mainstream Sacramento River channel. Today, less than five percent of the mainstream riparian forest remains. As in the Delta, wetland plants and riparian forests provide food and shelter for aquatic and terrestrial biota and greatly increase the hydraulic residence time of the system.

Much of the annual runoff volume of the Sacramento River system is stored in reservoirs; therefore, the Sacramento River and tributary flows are highly regulated and under the direct control of the Reclamation, DWR, and others. The main purposes of the reservoirs are flood control, storage for subsequent release to downstream diverters, and generation of electricity. Relative to the natural flow regime, the present river flows are lower in spring and winter but higher in summer and fall.

The historical 2-year floodplain along the Sacramento River channel is now a narrow terrace, while the frequently inundated portion of the floodplain is limited to the area between the levees and the flood bypass channels. Many miles of meandering natural backwater sloughs have been eliminated, replaced by straightened, lightly-vegetated drainage ditches whose flow levels are carefully controlled and discharged back to the river. Most of the natural flood basins are now only connected with the river system during floods, usually via the controlled flows in the bypasses. As a result, the once extensive riparian zones and wetlands that historically bordered lowland rivers and occupied much of the flood basins have been almost entirely lost, mostly converted to agricultural production. The loss of large areas of riparian forest and marshes, along with the noted geomorphic and hydrologic alterations, has severely altered the nutrient dynamics of lowland river floodplain ecosystems. In the minimal amounts of natural floodplain habitat remaining, it is only during extreme floods that river waters exchange materials and organisms with their riparian zones today (Whipple 2012).

The many rivers and streams that are tributary to the Sacramento River provide important riparian habitat that is critical for many aquatic and terrestrial species including salmonids, sturgeon, and numerous types of other native fish. The valley floor region adjoining the river provides some of the most important wintering areas along the Pacific Flyway for many varieties of waterfowl. The region also provides nesting and migration areas for threatened avian species including the Swainson's hawk, and numerous species of Neotropical migratory birds. All of these valuable resources are vital components of the ecosystem and contribute to the ecological health of the entire state.

The Sacramento Valley Region contains a large diversity of both lowland and upland habitats and species. Over 100 special-status wildlife and plant species occur in this region. The largest number of special-status plant species is found in grassland habitats, which includes vernal pools with the next-largest number occurring in chaparral and montane hardwood. The majority of the special-status wildlife species are associated with grasslands and fresh-water emergent wetlands, lakes, and rivers on the valley floor. Many of these species have been listed by Federal and State wildlife agencies as threatened or endangered because of habitat loss associated with agriculture, development, and water projects.

I. Ecosystem Processes

Sacramento Valley Streamflows. Healthy streamflows are natural seasonal patterns in late winter and spring. These include peak flow events that support many ecological processes and functions essential to the health of floodplains, riparian systems, and anadromous and resident native fish populations. The Sacramento River has a largely altered streamflow, in that storage reservoirs in the upper watershed reduce flood peaks during the winter and spring, and release the stored water during the summer months. Streamflow should be provided at levels to activate ecological processes that shape the stream channels and sustain riparian and riverine aquatic habitat, transport sediments, and sustain juvenile anadromous fish during the summer. These flow patterns can be attained by supplemental short-term releases from the major storage reservoirs to provide flows that emulate natural peak flow events, acquiring water rights from willing sellers, or developing supplemental supplies (e.g., conjunctive use and/or recycled water programs). The continued operation of flow monitoring stations specifically targeted for the management of anadromous fish migration will ensure the presence of, and facilitate the management of, dedicated instream flows acquired for anadromous fish.

Consistent with the ERP's regional approach, the Stage 1 Implementation Plan outlined the priorities, potential projects or programs, and science needs for regional issues and opportunities. ERP conducts adaptive management experiments for natural and modified flow regimes that promote ecosystem functions or otherwise support restoration actions. This priority is designed to address streamflows within the Sacramento Valley, as efforts to address natural and modified flow regimes that promote ecosystem functions and favorable biological responses are critical to the current and future management of the Sacramento Valley Region. Projects were implemented during Stage 1 that improved the scientific basis for flow-related actions and will inform ERP recommendations for future management priorities.

Additionally, projects were implemented that made progress on developing methods, including a combination of simulation models and physical measurements to evaluate flow, sediment transport, and other fluvial processes, to address ecological functions and native habitats and species in the Bay-Delta ecosystem. Studies continue to identify how the Sacramento River's current flow regime (i.e., the magnitude, timing, duration, and frequency of flow) and management actions (such as gravel augmentation and changes in bank armoring) influence habitats, species, and hydrogeomorphic processes in the riverine areas and riparian corridor. Additional research will improve process understanding and support the development of ecologically-based plans to restore conditions in the rivers, sloughs, and floodplains sufficient to meet restoration targets for Chinook salmon, steelhead, sturgeon, and splittail (Upper Yuba River Studies Program Study Team 2007; The Nature Conservancy et al. 2008).

Instream flow studies have been implemented to improve our understanding of the effects of flows and flow regimes on ecological and physical processes, especially their effects on fish populations in the Sacramento Valley. For example, projects on the Yuba River eliminated or substantially reduced potentially catastrophic flow fluctuations and associated biological impacts on fish habitat for at-risk species in the lower Yuba River and provided continuous release of cold water from Englebright Reservoir during such events. An ERP directed action proposal was funded on Clear Creek to assess the benefits of a flushing flow event on the floodplain and on instream habitat condition and to reactivate fluvial geomorphic processes which have been lacking since the completion of Whiskeytown Dam in 1963. These processes are fundamental for creating and maintaining the habitats of the Clear Creek ecosystem to support and to recover aquatic and riparian species, particularly fall-run, late-fall-run and spring-run Chinook salmon, steelhead trout, resident salmonids and native floodplain vegetation (Western Shasta Resource Conservation District 2011).

The vision for Clear Creek included increasing water releases from Whiskeytown Dam, which is also identified as an action required under CVPIA. To achieve this vision, an interdisciplinary team has worked directly with local entities. The Clear Creek Coordinated Resource Management Planning group, comprised of local landowners and stakeholders, and the Clear Creek Restoration Team have met since 1995 to plan, implement, and monitor projects using a multi-disciplinary restoration approach to benefit anadromous salmonids and the ecosystems upon which they depend. As a result of this effort, combined with CVPIA directives and OCAP Biological Opinion Reasonable and Prudent Alternatives to manage flows in the creek for the benefit of anadromous fish, increased minimum flows during the winter are largely responsible for the average four-fold increase in fall-run Chinook spawning escapement in Clear Creek over the baseline period (1967 to 1991).

The benefit of increased summer flows for threatened spring-run Chinook and steelhead has been demonstrated in rotary screw trap catches and in snorkel counts of adult spawners and their redds; monitoring which, in part, has been funded by ERP. The current instream flow prescriptions for Clear Creek, based on 1983 conditions, will be updated in the next few years to include temperature concerns, analysis of barriers to fish passage, recent developments in minimum flow setting methodology, and changes in the stream channel that have been ongoing since the installation of Whiskeytown Dam.

In addition to ERP-funded projects, the CVPIA has invested substantial funds into assessing instream flow requirements for anadromous fish in the Central Valley. In December 1994, the USFWS, Ecological Services, Instream Flow Assessments Branch proposed using the USFWS Instream Flow Incremental Methodology (IFIM) to identify the instream flow requirements for anadromous fish in selected streams within the Central Valley of California. Subsequently, several Central Valley streams, including Clear Creek, Battle Creek, Butte Creek, Cow Creek, and the Sacramento and lower American rivers have been studied via the IFIM process. Specific goals of these studies are to determine the relationship between streamflow and the availability of physical habitat for all life stages of Chinook salmon and to identify flows at which redd dewatering and juvenile stranding occur. The instream flow requirements for white and green sturgeon may also be studied; however, the inclusion of these species depends upon the availability of resources and data sufficient to enable identification of their habitats.

The ERP Strategic Goal 2 included restoring the variability of the flow regime and associated river processes "as an important component of restoring ecological function and supporting native habitats and species in the Bay-Delta ecosystem". The Sacramento River Ecological Flows Study was formulated to address CALFED program goals for determining variables necessary to provide habitat for sustainable levels of salmonid fish species. The Study will lead to specific recommendations regarding restoration and conservation of listed fish species. The Study built upon an earlier review of Sacramento River ecological flow issues conducted by Dr. Matt Kondolf for CALFED in 2000 (Kondolf et al. 2000). The Study did not focus on returning the river to historical and unaltered flow regimes, but identified how the river's flow regime and management actions influence habitats, species, and hydrogeomorphic processes in the riparian corridor to inform future management recommendations.

In 2001, ERP began funding The Real-Time Flow Monitoring Project which supports "real-time" operation and maintenance of flow monitoring stations on Sacramento River tributaries. These stations provide data on minimum instream flows and water quality for the recovery of spring-run Chinook salmon and Central Valley steelhead, and the management of fall-run Chinook populations. Information obtained from this project has and will continue to improve the ability to identify, manage, and maintain adequate stream reach flows.

There has been substantial effort to prioritize and implement environmental water acquisition in other programs such as CVPIA, which has addressed this ERP priority at some level. However, ERP has not specifically addressed this priority with funded projects. Projects are needed to:

- develop ecological and hydrodynamic modeling tools and conceptual models that describe ecological attributes, processes, habitats, and outflow/fish population relationships;
- develop ecological and biological criteria for water acquisitions;
- and evaluate previous water acquisition strategies and their biological and ecological benefits.

Sacramento Valley Stream Temperatures. Management of temperatures for tributaries in the Sacramento Valley Region will require coordination with all agencies and stakeholders. Stream temperature targets should be developed within the existing multi-purpose water resource management framework for each watershed. Virtually all streams in the region are regulated to some degree, and the regulated flow regimes influence water temperatures which frequently favor non-native fishes. Studies demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Specifically, modeling analyses revealed that managing Folsom Reservoir’s cold water pool using the monthly target release temperature regime developed for the Lower American River would: 1) provide water temperatures during the July through September period that would be lower than those realized under the Base Case condition, thereby providing more favorable conditions for over- summering juvenile steelhead; and 2) reduce average annual early life stage losses of Chinook salmon caused by elevated Lower American River water temperature during September, October, and November.

Exposure of Chinook salmon and steelhead populations to elevated water temperatures has been a major factor contributing to the decline of Chinook salmon and steelhead populations (Myrick and Cech 2001). Water temperature affects growth and survival for all life stages of salmonids. Spatial and temporal variability in water temperature has played a major role in determining the life history diversity of salmon and steelhead in the Sacramento River tributaries and the rest of the Central Valley. The construction of dams and other barriers have blocked access of steelhead and Chinook salmon to higher and cooler stream and river reaches in the Central Valley (Yoshiyama et al. 2001). Water diversions and dam operations, in addition to blocking access to upstream habitat, alter water temperature conditions. Agricultural and municipal diversions reduce river flow and potentially increase temperature during summer months (Myers et al. 1998, Myrick and Cech 2001). Irrigation return flows with elevated water temperature can affect instream water temperature.

Temperatures warmer than 55ºF (13ºC) increase mortality of female adult Chinook salmon prior to spawning, and migration was blocked when water temperature reached 69.8ºF (21ºC) in the Delta (Andrew and Geen 1960 in Raleigh et al. 1986, Hallock 1970 in McCullough 1999). In the Columbia River, a water temperature of 69.8ºF (21ºC) was lethal to steelhead acclimated to river temperature of 66.2ºF (19ºC). The response to warm temperature may be complicated by low DO concentrations. In the Delta, adult Chinook salmon avoided temperatures warmer than 66ºF (19ºC) when DO was less than 5 mg/l (McCullough 1999).

Chinook salmon eggs and larvae require temperatures between 39.2ºF and 53.6ºF (4ºC and 12ºC, respectively) for the highest survival rates (Myrick and Cech 2001). Survival of eggs was less than 50 percent when temperature is warmer than 60.8ºF (16ºC) (Alderice and Velsen 1978). Optimal water temperature for steelhead spawning and incubation is similar to that of Chinook salmon and has been reported to fall in the range between 39ºF and 52ºF (3.9ºC and 11.1ºC) (Myrick and Cech 2001). Steelhead eggs subjected to temperatures warmer than 59ºF (15ºC) are prone to increased mortality.

Marine (1997) and Myrick and Cech (2001) observed maximum juvenile growth rates at water temperatures between 62.6ºF and 68ºF (17ºC and 20ºC) and 66.2ºF (19ºC), for steelhead and Chinook salmon, respectively. Rich (1987) found that juvenile Chinook salmon from the Nimbus State Fish Hatchery died before the end of the experiment when reared at 75.2ºF (24ºC). Nimbus hatchery steelhead preferred temperatures between 62.6ºF and 68ºF (17ºC and 20ºC). Steelhead can be expected to show significant mortality at temperatures exceeding 77ºF (25ºC) (Raleigh et al. 1984, Myrick and Cech 2001).

Chinook salmon require cool temperatures to complete the parr-smolt transformation. Marine (1997 in Myrick and Cech 2001) found that smolt transformation was impaired for salmon reared at temperatures between 69.8ºF and 75.2ºF (21ºC and 24ºC) relative to those reared at cooler temperatures. However, field data indicate that Chinook salmon migrate through water temperatures greater than 68ºF (20ºC) in the Delta and successfully smolt and return as adults. Chinook salmon released at Ryde and migrating to Chipps Island undergo about 50 percent mortality at 73.4ºF (23ºC) (Baker et al. 1995).

Like Chinook salmon, steelhead smolt transformation requires cool temperatures, and successful transformation occurs at temperatures ranging from 42.8ºF to 50ºF (6ºC to 10ºC). Water temperature warmer than 55.4ºF (13ºC) appears to prevent the smolting process (McCullough 1999). Zaug and Wagner (1973 in McCullough 1999) found that steelhead require temperatures cooler than 55.4ºF (13ºC) to successfully complete smolt transformation. When temperature exceeded 55.4ºF (13ºC), the smoltification process was reversed and juveniles lost the ability to migrate. However, as with Chinook salmon, juvenile steelhead migrate through the Delta when water temperature exceeds 68ºF to 72ºF (20ºC to 22.2ºC).

Warm water temperature may be detrimental to annual production when a large proportion of the population experiences repeated exposure, increasing vulnerability to disease, high rates of predation by non-native fish species, and reduced survival during spawning, incubation, rearing, and migration (Sullivan et al. 2000, Myrick and Cech 2001).

The major influences on water temperature on the Sacramento River and its tributaries are reservoir operations (i.e., the timing, temperature, and magnitude of reservoir releases and total reservoir storage), ambient air temperature, flow, presence of riparian vegetation, and irrigation inflows.

In the upper Sacramento River, water temperature is mostly affected by reservoir operations. Until the completion of the Shasta Dam water temperature control device, water released below Shasta Dam in the spring was often too cold for rapid growth of juvenile fall- and late-fall-run Chinook salmon, and water released in August and September was often too warm for successful spawning and incubation of spring- and winter-run Chinook salmon eggs and alevins (Hallock 1987). The temperature control device allows water to be released from different depths or combinations of depths in the reservoir (CALFED 2000a). Warmer water from the upper part of the reservoir can be released in the spring and early summer, saving the cooler water from the lower part of the reservoir for release in the summer and fall.

Winter-run Chinook salmon are unable to spawn successfully below Red Bluff Diversion Dam because of high water temperatures in most years (Hallock and Fisher 1985). High water temperature in the mainstem and tributaries limits downstream extent of suitable spawning habitat for spring-run Chinook salmon, which require cool deep pools to hold-in over warm summer months (e.g., Beegum Creek in some water year types). To a lesser extent fall-run Chinook salmon are also limited by instream temperatures. Below Tehama County, water temperature of the river is no longer affected by reservoir operations; it is mainly determined by the presence of riparian vegetation, weather and hydrologic conditions, and temperature of irrigation inflows.

In the Feather River below Oroville Dam, water temperature is influenced by the operations of Oroville Dam, Thermalito Diversion Dam, and Thermalito Afterbay Outlet. The Thermalito Afterbay functions as a warming basin for irrigation water going to rice fields, so water temperature is elevated in the section of Feather River between the Thermalito Afterbay Outlet and the mouth of Honcut Creek (DFG 1993). These elevated temperatures may negatively affect spring-run and early fall-run Chinook salmon. Field observations in 1992 indicate that water temperatures in the spring may be unsuitable for juvenile salmon (USFWS 1995b).

In the Yuba River, water temperature is primarily affected by ambient air temperature and the temperature of releases from New Bullard's Bar and Englebright Reservoirs. Because of its depth and size, cold water can always be released from New Bullard's Bar Reservoir (USFWS 1995b). However, the cold water from New Bullard's Bar Reservoir warms within Englebright Reservoir, and the depth from which water is released from Englebright Reservoir cannot be controlled. Water temperature below Englebright Reservoir is considered acceptable for salmonids; however, summer and fall water temperature below Daguerre Point Dam (12.5 miles downstream of Englebright Dam) may exceed suitable ranges for salmonids (CALFED 2000a).

In the Bear River, water temperature is affected by the operations of Camp Far West Reservoir and other reservoirs upstream and by diversions downstream of the reservoirs. Low flows below Camp Far West Reservoir have resulted in elevated water temperatures in the lower Bear River during critical life stages of Chinook salmon and steelhead (USFWS 1995b).

In the American River, water temperature is influenced by the operations of Folsom Reservoir and Lake Natoma. Folsom Reservoir has a relatively low storage capacity, which limits the ability of managers to use water releases to control downstream water temperatures (USFWS 1995b). Water release shutters on Folsom Dam allow water to be released from four different layers into the lower American River. When water temperature needs to be cooled, water can be released from the lower temperature control shutters or from the lower river outlets below the temperature control shutters, bypassing power generation (DWR and Reclamation 2001). At Nimbus Dam, turbine intakes draw in the heated surface waters of Lake Natoma rather than the cooler, deeper flows from Folsom Dam. When turbines are not operating at Nimbus Dam, heated surface water from Lake Natoma is released over spillways to the river below the dam (CALFED 2000b). High summer and fall water temperatures in the Lower American River limit Chinook salmon and steelhead spawning, incubation, rearing, and migration (USFWS 1995b, CALFED 2000b).

Although steelhead and Chinook salmon in the Sacramento River and its tributaries would benefit from improved water temperature conditions, the population response is currently uncertain. Other factors may limit survival and production of each life stage, including passage conditions, the quantity and quality of spawning gravel, rearing habitat and food availability, and downstream and Delta conditions.

Maintaining stream water temperatures in the Sacramento Valley Region should be addressed through integrated water and temperature management programs that seek to conserve cool water reservoir pools for release later in the summer and by investigating feasibility of modifying water release outlets on existing dams to provide a greater ability to fully utilize the cold reservoir water. The extent of cool water habitat below the dams depends on the amount of cold water released from the dams, the extent of shade along the river channels provided by riparian vegetation, and the amount of warm water discharge into the rivers from urban and agricultural drainage.

Maintaining cool water below the dams is essential to sustain ecological system health and maintain salmon and steelhead in these rivers. Some of the identified ways to restore Sacramento Valley stream temperatures include:

- Provide target flows in the American River by modifying CVP operations and acquiring water as needed from willing sellers, with consideration given to available carryover storage and needs determined by the water temperature objectives.
- Reconfigure Folsom Dam shutters for improved management of Folsom Reservoir's cold water pool and better control over the temperature of water released downstream.
- Address temperature barriers that impede access for salmonids.

Sacramento River Channel-Forming Processes. Channel-forming processes are key ecological processes that include stream meander, natural floodplains and flood processes, and coarse sediment supply. These channel-forming processes affect the geomorphology (physical attributes) of rivers. The physical attributes of a river are connected to food production (productivity) and overall ecosystem health. Physical processes in the Sacramento Valley Region related to fluvial geomorphology and hydrology are extremely important in the restoration of ecosystems. Better scientific understanding is needed to inform potential restoration.

Success in restoring riparian and aquatic communities depends on how well the physical processes that maintain dynamic stream channels are understood. Understanding the relationships between fluvial processes and riparian regeneration will improve the success of immediate and future restoration efforts.

Rivers are naturally dynamic. They migrate across valley floors as flows erode banks and deposit sediment on point bars. They occupy different channel alignments through channel avulsion. They periodically inundate floodplains. They recruit and transport sediment, and they drive the establishment and succession of diverse riparian plant communities. These physical processes provide the energy and material necessary to create and maintain healthy and diverse riverine habitats that support native populations of plants, fish, and wildlife. The optimum scale and balance of inputs--flow, sediment, organic material--and channel modifications that will restore riverine ecosystem function is generally unknown. How channels and habitats downstream of dams have adjusted to the post-dam flow regime, and how, therefore, the reinvigoration of dynamic riverine processes will affect overall habitat is also unknown (CALFED 2000b).

Larsen et al. (2006) used a meander migration model to examine the relationship between setback distance and habitat formation through a measure of the land reworked over one hundred years of channel migration and cutoff events under different setback levee scenarios on a 28 km reach of the Sacramento River. The study section showed complete cutoff restriction at distances less than about one channel width (300 m), and showed no cutoff restriction at distances greater than about three channel widths (700 m). Three basic patterns of rate of land reworked based on different migration and cutoff dynamics were apparent – complete restriction of cutoffs, partial restriction of cutoffs, and no restriction of cutoffs. Results suggest that management decisions concerned with reworked land could identify the site-specific "restriction of cutoff" thresholds to optimize habitat benefits versus cost of acquired land.

Floodplains and Flood Processes. Maintaining existing and restoring inaccessible floodplains are important ecological actions needed to improve the Sacramento Valley. Protecting the natural stream meander corridor along the Sacramento River will contribute to improved connectivity of the river with its floodplain. River-floodplain interactions are important ecological events that occur at varying intervals, ranging from annual inundation of some of the floodplain to flow or flood events that inundate most of the floodplain.

Frequent (often annual) floodplain inundation was an important attribute of the historical aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which: 1) reduces the cutting down of the channel, 2) acts as a pressure relief valve, permitting a larger range of sediment grain sizes to remain on the channel bed, 3) increases the complexity and diversity of instream and riparian habitats, and 4) stores floodwater (thereby decreasing flooding downstream). The floodplain also provides shade, food organisms, and large woody debris to the channel.

Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. Reestablishing active inundation will probably require major land purchases or easements, and financial incentives to move existing floodplain uses elsewhere, as has been done in the Midwest since 1993. Obviously, artificial inundation events will have to be planned to take into account other needs for stored water, including increased summer flows.

Coarse Sediment Supply. The supply of beneficial gravel on the Sacramento River is severely impaired by reduced inputs from tributaries and blockage of upstream sources by Shasta and Keswick dams. The supply of sediments supports stream channel maintenance and sustains riparian and riverine aquatic habitats. The CALFED Science Program funded research that measured meander migration rates in the Sacramento River between Red Bluff and Colusa (Constantine et al. 2006). Results show two temporally persistent patterns in migration rates: 1) a previously recognized downstream alternation of active and stable reaches, and 2) a mid-basin peak in migration rates. Stable reaches form where the river contacts resistant bank material, and these reaches follow a distinctive temporal evolution. Among active reaches, migration rates increase through a zone of declining bed shear stress and stream power and peak where sinuosity and bankfull discharge are greatest. Bankfull discharge and migration rates decline where frequent overbank flooding occurs. Increasing interaction of the channel with levees may contribute to the decline of migration rates. These results suggest that both point bar growth and curvature, drive migration in active portions of the river, and discharge plays a role in controlling migration rates by limiting the river's ability to erode and transport bank material.

Hitchcock et al. (2005) mapped geomorphic landforms and geologic deposits along the lower Sacramento, San Joaquin, and Cosumnes rivers for input into ecosystem restoration planning and levee engineering. This research provides a record of long-term changes along the lower Sacramento River that have shaped current conditions. Their maps, which cover nine USGS quadrangles from Courtland to Rio Vista, identify geomorphic landforms along the river, as well as associated sediments, including older, denser sediments that are stable foundations for setback levees. The mapping shows the distribution of remnant sediments from historical hydraulic mining that washed downstream into river floodplains during the 19th century. Currently, these historical sediments, with potentially high mercury contents, are stored along the margins of and within historical floodplains of the Sacramento River and are separated from the current river system by the modern levee system.

The Sacramento River Ecological Flows Study (Sac EFT) is quantifying key aspects of a "naturalized" flow regime of the Sacramento River that is compatible with flood damage reduction, agriculture, diversions, storage and conveyance. Stillwater Sciences (2007) inferred that the cumulative deficit of coarse sediment since dam construction (i.e., more than 60 years) has been on the order of 3 million cubic yards (cu yd) for the reaches downstream of Shasta Dam. The deficit of coarse sediment from the upper watersheds was exacerbated by the nearly 7 million cu yd of sediment that was mined from the river and floodplains for dam building, and the 1.8 million cu yd of aggregate that was mined to support urbanization of Redding (Stillwater Sciences 2007). As part of the ongoing gravel study, Stillwater Sciences is using a new sediment transport model to predict bedload transport rates under the current hydrology. In this way, the model will provide a much more reliable estimate of the overall post-dam coarse sediment deficit, and will provide an understanding of how it affects the extent and quantity of gravel in storage on the river bed.

Numerous projects supported by various funding sources (ERP, CVPIA, and CALFED Watershed Program) have assessed coarse sediment supplies and needs linked to erosion and deposition for purposes of maintaining or improving fish spawning areas. CVPIA projects have been implemented to increase the availability of spawning gravel and rearing habitat for Chinook salmon and steelhead trout in the reach of the mainstem Upper Sacramento River from Keswick Dam downstream to Red Bluff Diversion Dam, in Clear Creek, and in the reach of the American River downstream of Nimbus Dam. The conditions in the regions where gravel was placed have been monitored and compared with control sites/conditions in adjacent areas.

Fine sediment loads within the Clear Creek watershed are being monitored to assess the potential impact to instream habitat quality. However, additional projects are needed elsewhere in the Region to assess potential adverse ecological effects, particularly on salmonids, of anthropogenic fine sediment loads in spring-run Chinook salmon streams. Where appropriate, these additional projects should determine anthropogenic sources and magnitudes of loads, as well as develop, test, implement, and evaluate actions to reduce fine sediment loads from human activities.

Stream Meander. The meandering process for the Sacramento River provides much of the habitat required by anadromous fish populations that depend on the river for spawning, rearing and migration. A meandering stream provides the continual supply of coarse sediments, regeneration of the riparian corridor and the rejuvenation of gravels used for fish spawning and invertebrate production.

The Cottonwood Creek watershed is a large west side tributary to the Sacramento River. It is unregulated and is a substantial contributor of spawning gravel to the upper Sacramento River. The ERP-funded Cottonwood Creek Channel Restoration Planning/Geomorphic Analysis provided a cursory geomorphic analysis of approximately 20 miles of lower Cottonwood Creek and documented long-term changes in the lower alluvial reaches attributable to aggregate extraction in excess of annual replenishment rates (Graham Matthew and Associates 2003).

II. Habitats

Essential Fish Habitat. Portions of the Sacramento, Yuba, Feather, and Bear rivers, and Clear, Cow, Bear and Battle creeks have been identified as EFH, based on the definition of waters currently accessible to salmon. The vision for EFH is to maintain the quality of habitat available through actions directed towards improving streamflows, coarse sediment supply, water quality, access and passage, stream meander, natural floodplain and processes and maintaining and restoring riparian and riverine aquatic habitats.

ERP Goal 4 is to protect, restore, or enhance habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics. As a result of the efforts of ERP and its partners, several thousand acres of habitat has been purchased, protected via conservation easements, and/or restored to native habitat. Key areas where this has been implemented include the mainstem Sacramento River, Deer Creek, and Mill Creek. ERP and EFH have a similar vision for habitat restoration and ERP will continue to support projects that target conservation priorities under Goal 4 (see Section 5).

Freshwater Fish Habitats. Freshwater fish habitats and native fishes are closely linked in the Central Valley as the health of native fish populations is largely dependent on the health of their habitats. This habitat type includes standing waters, flowing waters, and artificial habitats. Each habitat supports a different assemblage of organisms, and quite likely many of the invertebrates and plants are still unrecognized as endemic forms, thus, systematic protection of examples of the entire array of habitats in the region provides some assurances that rare and unusual aquatic organisms will also be protected, preventing contentious endangered species listings.

Riparian and Riverine Aquatic. Riparian and riverine aquatic habitats support a wide diversity of aquatic and terrestrial species, and are important to the health of the rivers by providing shade, insects and organic debris important to the aquatic food web, and soil and bank protection. The riparian corridors and related riparian and shaded riverine aquatic habitats are impaired by lack of natural stream meander; river channel confinement by levees; and streamside vegetation loss to animal grazing, levee construction, and agricultural clearing. Healthy riparian corridors in the Sacramento Valley provide a migratory pathway between lower and higher elevation habitats for terrestrial species. Shaded riverine aquatic habitat provides shade and cover for juvenile fish.

Over fifteen native trees and shrubs occur in the Central Valley riparian forests, woodlands and scrubs (Conard et al. 1980). Flow regime, disturbance and species attributes determine the species composition and physical structure of this woody vegetation. Though flow regime influences the dispersal, establishment, growth, and survival of all the woody riparian species, Fremont's cottonwood and the willow species are particularly dependent upon specific hydrologic events for their recruitment. During seed release, flows must be high enough to disperse seeds to surfaces where scouring by subsequent flows does not occur, yet not so high that seedlings desiccate after flows recede, and flows must recede gradually to enable germination and establishment of seedlings while the substrate is still moist (Mahoney and Rood 1998, Shafroth et al. 1998, Scott et al. 2000). Fremont's cottonwood and willow species are fast-growing, shade intolerant and relatively short-lived (Burns and Honkala 1990, Sudworth 1908, Strahan 1984). Within 10–20 years, initially shrubby thickets have reached 10–40 ft. in height. Other species, such as Oregon ash and valley oak, establish concurrently or subsequent to the willows and cottonwood, grow more slowly but are more tolerant of shade, and are longer-lived (Burns and Honkala 1990, Tu 2000). In the absence of frequent disturbance, these species enter the canopy, particularly after fifty years as mortality of willows and cottonwood frees space. Conversely, frequent disturbance prevents the transition to mature mixed riparian or valley oak forests.

Woody material is important because it provides the hydraulic diversity necessary for selection of suitable velocities, access to drifting food, and escape cover from predatory fish (Peters 1998). Additionally, the input of large woody material into the river system increases the complexity of habitat and fosters the creation of pools for holding juvenile salmon during high flow events (Larson 1999, Macklin and Plumb 1999). Shade reduces daily temperature variability and maximum temperature, maintains DO, and may help maintain base flows during dry seasons (CALFED 2000b, Haberstock 1999, Slaney and Zaldokas 1997, Whitting 1998). Shaded riverine aquatic habitat cover is important to juvenile Chinook salmon and steelhead because it provides high-value resting and feeding areas and protection from predators. In studies comparing riprapped and non-riprapped banks, juvenile Chinook salmon were shown to prefer non-riprapped areas (Shaffter et al. 1983, Peters et al. 1998, Michny and Deibel 1986).

The loss of riparian vegetation and shaded riverine aquatic habitat cover is potentially a factor in the decline of all fish species. Riparian vegetation filters sediments, provides woody debris and organic matter, modifies channel pattern and geometry, creates cover, and provides habitat for aquatic invertebrates eaten by salmonids. For these reasons, stream sections shaded by riparian vegetation provide optimal conditions for rearing and resting areas for adult Chinook salmon and steelhead migrating upstream (CALFED 2000b, Haberstock 1999, Slaney and Zaldokas 1997, Raleigh et al. 1984, 1986).

The acquisition of riparian habitat and adjacent land has been a priority for the USFWS and CDFW since the early 1960’s. As of 2010, the Sacramento Wildlife Refuge (SWR) consisted of nearly 10,000 acres of riparian and agricultural habitats, owned in fee title, and distributed among 26 individual units. An additional ±1400 acres is held by the SWR as a ranch easement. The other major aggregation of conservation land along the Sacramento River is the CDFW Sacramento River Wildlife Area, which, in 2007, consisted of ±4150 acres distributed among 13 management units. Additionally, The Nature Conservancy began the Sacramento River Project in 1988. Key project partners include the USFWS, the US Army Corps of Engineers, CDFW, DWR, the California Department of Parks and Recreation, the California Wildlife Conservation Board, River Partners, and the Sacramento River Conservation Area Forum. These partners act in coordination to acquire, protect, and restore additional acreage along the Sacramento River corridor.

Golet et al. (2008) published the results of several years of species surveyed in the wildlife areas to determine success of restoration efforts on protected riparian habitat along the river. They found that restored areas support a full complex of riparian habitat components approximately ten years after restoration was initiated. At about eleven years, restored areas support cavity nesters, sensitive crevasse-roosting bat species, and a diversity of insect species. However, results show that non-native invasive species remain a problem. This requires on-going inventories, assessment, management, and control.

Riparian restoration projects were also found to restore non-target species. Williams (2007) investigated bee and flowering plant communities at restored sites and riparian remnants. Average richness and abundance did not differ between sites types, within five to ten years after planting at the restored site, indicating that restored habitats can support abundant and diverse pollinator communities. A study compared surface-active beetle assemblages in remnant and restored riparian forests of varying ages and analyses indicated that as restoration sites age, their assemblages increasingly resembled those found in remnant riparian forests (Hunt 2007). Small (2007) found no difference in nest predation rates on restoration and mature remnant forest sites. Small (2007) also found that flood timing influences nest predation rates for black-headed grosbeaks (*Pheucticus melanocephalus*), possibly by driving mammalian nest predator population cycles.

Many projects have provided planning and design phase reports, funded acquisition, and supported permitting and restoration along the Sacramento River in the Red Bluff and Colusa sub-reaches and have or will provide over 3,500 acres of restored or protected riparian habitat, including nearly 40 river miles of bank that could be suitable bank swallow habitat or could be allowed to erode and develop into suitable bank swallow habitat because of setback levees. The area restored or protected should provide the basis for up to five bank swallow preserves and may provide for the target of 5,000 bank swallow burrows. Monitoring for bank swallow habitat within the specified area is necessary to ensure appropriate habitat has been protected and/or restored.

Upland Areas. Upland habitats are important for waterfowl, giant garter snakes, and raptors such as the Swainson's hawk. Perennial grasslands are an important component of the American Basin providing habitat for many plant and wildlife populations. Protection of these habitats will expand the outer edges of wetlands and restore grasslands and remnant oak woodland and oak savanna where possible.

Sustainable grasslands provide contributions to flood control function by slowing and extending storm events and by reducing erosion. This type of habitat is adversely affected by land use, land conversion, and proliferation of non-native plant and grass species. Control of invasive non-native plant species is a significant stressor and control programs need to be developed for protecting and restoring perennial grasslands.

Agricultural Lands. Agricultural lands are important winter feeding grounds for sandhill cranes, various species of waterfowl, and year-round for resident bird species. Protecting and enhancing agricultural lands for wildlife by encouraging production of crop types that provide high wildlife habitat value, agricultural land and water management practices that increase wildlife habitat value, and discouraging development of ecologically important agricultural lands for urban or industrial uses in the Sacramento Valley. Vegetation management of agricultural lands could provide wildlife habitat at many locations, including rice checks, irrigation ditches, lowlands, ponds, fallow lands, fence rows, and other areas unsuitable for agricultural land use. Agricultural crop types that present excellent opportunities for enhancement include rice, alfalfa and pasture, corn and grain, and certain rowcrops. Enhancing agricultural lands adjacent to existing wildlife habitat areas, such as refuges, would be particularly beneficial.

Seasonal Wetlands. Restoring seasonal wetlands in combination with other wetland habitat types will help restore and maintain the ecological health of aquatic and terrestrial resources in the Sacramento Valley. Food web processes will be supported and the effects of contaminants reduced. Seasonal wetlands will provide high quality foraging and resting habitat for wintering waterfowl, greater sandhill cranes, and migratory and wintering shorebirds.

III. Stressors

Restoration of ecosystem processes to help improve the quality and extent of desirable habitats is only part of the solution to species recovery in the Sacramento River Valley and, by extension, the Delta. ERP identified several stressors that negatively affect the Sacramento Valley's ecosystem health as measured by native species, ecological processes, and habitats. The focus in this element of the Conservation Strategy for the Sacramento River Valley is on stressors including non-native invasive species, water and sediment quality, water diversions, and barriers to connectivity of habitats (such as levees, dams and other structures).

Loss of Habitat. Riparian forest was naturally distributed along most of the entire length of upland river and stream channels, supporting highly diverse assemblages of insects, amphibians, reptiles, birds and mammals. There has been a widespread and substantial loss and degradation of riparian zones throughout the region. Perhaps as many as 25% of the species dependent upon riparian habitat of the upland region are now at risk of extinction.

It has been estimated that due to dams and other barriers, about 90% of historical salmon spawning habitat in the Sacramento-San Joaquin system is no longer accessible to these fishes. The amount of large woody debris in streams, which normally originates in nearby forests, has declined markedly throughout much of the Sierra, degrading in-stream habitat by reducing complexity. Non-native fishes are now widespread and abundant throughout much of the upland system, and continue to adversely affect the distribution of a wide range of native species.

Water quality problems plague much of the upper watershed. Downstream of dams, altered channel morphology and benthic sediment characteristics, as well as elevated turbidity and temperatures are widespread. Mining, logging, urbanization, and recreational use have increased sediments, nutrients, and bacterial and chemical pollution of once pristine mountain streams (The Bay Institute, 1998)

Changes in Flows. The main changes evident below the terminal storage dams are a pronounced reduction and temporal shift in flows, and reduced monthly and inter-annual variability. In some cases (most commonly in the Sacramento River Basin), the average winter/spring flows are now lower, and summer/fall flows higher than they were under natural conditions. For example, on the Sacramento River (at Red Bluff), there has been a reduction in the median monthly discharge from December through April, and an increased discharge (some of which originates as diversion from the Trinity River) from June through October. Additionally, the magnitude of the mean difference between high and low monthly discharges within the year has been reduced by about half.

Non-Native Invasive Species

Non-native Invasive Species (NIS). NIS threaten the Sacramento River Valley Region by producing changes throughout the ecosystem including alteration of habitats, competition with native species for food, space, or other resources, and direct predation of native species. Following loss of habitat, NIS represents one of the greatest impediments to restoring habitats and populations of native species (CALFED 2000a). To address and manage NIS issues, the Bay-Delta Non-native Invasive Species Program (NISP) was created in 1998. Program goals are to: 1) prevent new introductions, 2) limit the spread of or eliminate populations through management, and 3) reduce the harmful ecological, economic, social and public health impacts resulting from infestation of NIS. The NISP provides technical assistance and coordination to regional efforts and watershed groups focusing on assessment and monitoring for NIS to improve rapid response to new invasions. These findings along with research and technology transfer from other partners resulting from ERP funding, have provided technical assistance for restoration projects and to inform implementation of California's Aquatic Invasive Species Management Plan.

NIS Plants. In the Sacramento River tributaries, projects have been funded to reduce the negative impacts of *Arundo, Tamarix*, and other invasive plant species. The program-wide *Arundo* Eradication and Coordination Project was funded through 2009 as an ongoing effort to control invasive riparian plants in order to allow native riparian plant species to propagate naturally. This project is planned to remove *Arundo* (commonly known as giant reed) from priority areas including the Lower American River (which provides critical habitat for the federally-listed valley elderberry longhorn beetle), North Fork American River, and Arcade, Dry, Morrison and Elder creeks. Significant progress was also made in determining physical and chemical eradication methods for managing *Arundo*, and *Tamarix* (commonly known as salt cedar) on watershed tributaries and developing recommendations for active restoration following eradication. A follow-up project, the Terrestrial Weed Eradication Protocol, continues to monitor the efficacy of the removal efforts conducted by *Arundo* Eradication and Coordination Project. Another ERP project identified and removed giant reed and salt cedar from infested areas on Deer Creek, Red Bank Creek, and Reed's Creek in Tehama County.

Additional progress on non-native invasive plant species has been made by watershed groups and other conservation-oriented entities. For example, the Redding Rotary Club received funds from various sources to remove *Arundo* from all of Shasta County by 2010. Similarly, the Cottonwood Creek Watershed Group identified the presence of giant reed and salt cedar during their ERP-funded Watershed Assessment process. The group subsequently obtained funds from the Natural Resource Conservation Service (NRCS) to map nearly all riparian habitats within the watershed boundary. This inventory and map included location information on non-native plant species, with an emphasis on giant reed and salt cedar and is being used to implement an AFRP funded eradication project for these and other noxious plant species.

Water and Sediment Quality

Water Quality. The Sacramento River Valley receives a large variety of potentially toxic chemicals, including but not limited to pesticides from agricultural and urban runoff, contaminants discharged from wastewater treatment plants, mercury from gold mining and refining activities, and other metals from different mining activities. Scientists must consider the synergistic effects of multiple contaminants when looking at environmental water quality. Some stream segments of the Sacramento River and its tributaries are listed as “impaired” by various contaminants (SWRCB 2007). A designation of “impaired” stream means that the waterbody is not meeting the established water quality standard.

The Clean Water Act requires states to maintain a listing of impaired water bodies for the purpose of establishing a TMDL for each pollutant/waterbody combination. The most prevalent listings in the Sacramento River Basin are for OP pesticides and mercury. This section briefly outlines some of the environmental water and sediment quality concerns.

Contaminants. Contaminants are organic and inorganic chemicals and biological pathogens and metabolites that can cause adverse physiological response in humans, plants, fish, or wildlife. Contaminants are found in many forms and have the ability to affect the ecosystem in many ways and at different life stages of individual species; they may cause acute toxicity (mortality) or chronic toxicity (reduced growth, reproductive impairment, or other subtle behavioral effects). They can also affect the sustainability of healthy aquatic food webs and interdependent fish and wildlife populations. Some contaminants occur naturally at low levels, but with human disturbance, contaminants can be present in the environment at amounts or concentrations high enough to pose life-altering effects. Contaminant loading from the Sacramento River Valley watershed has a significant effect on the overall Bay-Delta ecosystem. Controlling these contaminants at their sources must be an important component of ecosystem restoration.

Pesticides. Herbicides and pesticides have potential toxicity to many different species in the Sacramento Valley. Testing of ambient water and wastewater treatment facility discharges to determine if it is harmful or toxic to aquatic organism (toxicity testing) shows that pesticide toxicity could be an important impediment to survival of some species in the mainstem Sacramento River as well as in tributaries to the Sacramento River. Greater understanding of pesticide occurrence, distribution, and effects under conditions typical of Sacramento stream and river environments is a critical need for addressing this threat. The Central Valley Regional Water Quality Control Board is in the process of amending their Basin Plan to address certain pesticides in surface water. The primary goal of the Pesticide Basin Plan Amendment is to provide a clear regulatory framework for the protection of aquatic organisms from selected pesticides found in runoff in the Sacramento and San Joaquin rivers' watersheds, including the Delta. The Basin Plan Amendment will be focused on those pesticides that have the greatest potential to impact aquatic life. ERP should continue to work cooperatively to address this issue, as pesticides can impact the entire food chain and have indirect impacts on all the listed species of concern. Past efforts have supported the development of methods for analyzing pyrethroid insecticides in water, colloids, sediment, and biota. ERP should also work towards developing pilot/demonstration projects that can test and evaluate restoration and management practices that reduce contaminants and other stressors, such as pesticides.

Mercury and Acid Mine Drainage. Historical mercury mining in the Coast Range and mercury use associated with gold mining in the Sierra Nevada have left an environmental legacy of pervasive mercury contamination in many northern California watersheds. Mercury can enter streams or aquatic systems through either atmospheric deposition or transport from geological or man-made sources. Several processes contribute to the subsequent bioaccumulation of mercury in fish tissue. Because of the presence of mercury in the tissue of certain fish species, advisories have been posted for several water bodies, and more advisories are planned, both within the Sacramento River Basin and in the San Francisco Bay.

Mercury exists in many forms in the environment. The dominant forms of inorganic mercury occur as mining wastes (e.g., cinnabar and quicksilver). Under certain environmental conditions, this inorganic mercury can be converted through microbial activity into methylmercury, a more toxic, organic form. Methylmercury readily bioaccumulates in aquatic organisms. Because methylmercury increases in concentration with each successive level of the food chain, the species at greatest risk to exposure are top predators including fish species such as bass and sturgeon, fish-eating birds like eagles, and humans.

Researchers from the CALFED ERP directed action for mercury provided great insights on mercury in the environment. These early findings included:

- The aquatic food chain below mine sites and hot springs were greatly affected by methylmercury.
- A predictive relationship exists between unfiltered methylmercury in the water and methylmercury bioaccumulation in invertebrates and small fish.
- Mercury in lower trophic level bioindicator organisms is predictive of mercury in large fish.

- Concentrations of mercury in sport fish from the Delta represent a potential human health concern.
- Mercury tissue concentrations in largemouth bass have not changed in the last 30 years.
- Methylmercury primarily accumulates in the base of the food web in the spring and early summer.
- Mercury concentrations in avian eggs vary greatly within the Bay-Delta system but were highest in fish-eating birds (above embryotoxic thresholds).

Studies subsequent to this focused on the Delta and on wetlands, as a concern that emerged from the first study was that CALFED restoration activities could unintentionally exacerbate mercury methylation and provide favorable conditions for the bioaccumulation of methylmercury in wildlife. These more recent studies showed that:

- Methylmercury from the Sacramento River is a major source of methylmercury introduced to the Delta (especially under high flow conditions).
- Methylmercury can be lost from the water column. The two processes that seem responsible for this are photodemethylation and particle settling.
- Some wetlands have lower methylmercury exposure than others. Habitats identified as being relatively high in methylmercury exposure to wildlife include high tidal marsh and seasonal wetlands (e.g., floodplains). Those with comparatively low methylmercury exposure occurred in perennial aquatic habitats and low tidal areas.
- In developing bird embryos, exposure to both methylmercury and selenium at certain concentration resulted in greater effects than were seen from exposure to either of these alone.

Data from these studies were used by the Central Valley Regional Water Quality Control Board in the development of the methylmercury TMDL for the Delta (CVRWQCB 2010).

Due to the rich mining history in the Sacramento River watershed, mercury contaminated sediments are a concern as the ERP moves forward with restoration efforts. Careful planning of projects, associated pre and post project monitoring of restoration and mine remediation sites, and the use of best management practices to control mercury and methylmercury transport and production will be important next steps from both the environmental and regulatory views.

Water Diversion and Barriers

Water Diversions. Water diversions ranging from several cfs to several thousand cfs lead to the loss of millions of juvenile anadromous and resident fish. Significant progress has been made in screening the larger diversions, but screens are needed on the remaining unscreened large, medium-sized, and small diversions. Losses at these diversions continue to threaten the health of the anadromous fish populations.

Unscreened diversions cause direct mortality to young fish; the level of mortality is likely influenced by the number of young fish present, diversion size, and diversion timing. Juvenile Chinook salmon, steelhead, green and white sturgeon, splittail, and American shad are lost at water diversion sites all along the Sacramento River and tributaries during the spring-to-fall irrigation season. Efforts are ongoing to screen diversions along the Sacramento River to the extent that they no longer impair other efforts to restore anadromous and resident fishes.

The installation of positive barrier fish screens does not reduce the amount of water diverted from Sacramento Valley streams, but screening is encouraged to reduce the mortality resulting from the direct entrainment of young fish. Sacramento Valley Region restoration priorities will encourage the restoration of small tributaries by evaluating the feasibility of screening.

The milestone for screening diversions in the Sacramento Valley during Stage 1 was to install positive barrier fish screens on all diversions greater than 250 cfs and 25% of all smaller unscreened diversions. Significant progress has been made toward completing this milestone. Most large diversions (greater than 250 cfs) have been screened, or are in the process of being screened. Approximately ten percent of diversions less than 250 cfs in the Sacramento have been screened to date and additional small diversions are in the process of being screened under the Sacramento River Valley and Sacramento-Central Valley Fish Screen Programs. Priority should be placed on screening all diversions to improve fish passage and protect all life history stages of anadromous fish.

Comprehensive studies of how effectively fish screens protect species are still needed to better prioritize allocation of expenditures. To meet this need, a pilot project is currently underway in the Sacramento Valley that is conducting biological assessments of smaller (less than 150 cfs) unscreened diversions. Under the Sacramento Valley Fish Screen Program biological assessments of fish loss are conducted at diversions for up to two irrigation seasons prior to installation of fish screens. In addition, another project is underway in the Sacramento Valley that is expected to screen four diversions that range from 40 to 85 cfs.

Dams and other Structures. Dams and their associated reservoirs block fish movement, alter water quality, remove fish and wildlife habitat, and alter hydrological and sediment processes in the Sacramento Valley Region. Other human-made structures may block fish movement or provide habitat or opportunities for predatory fish and wildlife, which could be detrimental to fish species of special concern. Perhaps the greatest potential for anadromous fish restoration can be realized by reestablishing access to some of these former habitats, especially for those fish that are dependent upon habitat in mid- to upper-elevation stream reaches, such as steelhead and spring-run Chinook salmon.

Adult spring-run Chinook are deterred by intermittent flow in Lindo Channel and inadequate fish passage at the One and Five Mile Recreation Areas and at Iron Canyon in upper Bidwell Park. Marginal spawning and rearing habitat in Big Chico Creek and Lindo Channel below the Five Mile Recreation Area is used by fall-run Chinook salmon. Big Chico Creek and Lindo Channel are used by many interests for a variety of purposes, including wildlife habitat, anadromous fisheries reproduction and rearing, urban storm drainage, flood control, and recreation. Salmon and steelhead passage problems at Iron Canyon and Five-Mile Diversion should be improved by repairing weirs, culverts and fishways.

Excluding access above central valley dams removes 80% of historic spawning habitat for spring-run Chinook salmon and steelhead and almost 100% of winter-run Chinook salmon (Yoshiyama et al. 2001 and Lindley et al. 2007 in Cummins et al. 2008). Providing access to historical habitats could also reduce the reliance on low-elevation, valley-floor reaches that require large amounts of water to maintain suitable temperatures, thus could potentially reduce overall water costs for anadromous fish restoration.

Adult and juvenile anadromous fish within the Sacramento Valley ecosystem are affected directly and indirectly by diversion dams and other structures. Dams and structures delay or prevent the upstream migration of adult fish during their spawning run, which lowers the reproductive success and viability of the entire population. Diversion structures can also injure young fish as they migrate downstream or cause disorientation, making them more susceptible to predation. Water diversions also affect the Sacramento Valley ecosystem through entrainment of fish and other aquatic organisms.

Instream structures can impair up and downstream adult and juvenile fish passage. Connections between upstream fish holding, spawning, and rearing areas in the Feather and Yuba rivers and the Sacramento River should be improved and maintained to permit unobstructed or unimpaired fish passage. Fish passage at Daguerre Point Dam on the Yuba River needs to be improved to permit easier up and downstream passage for steelhead, sturgeon and Chinook salmon.

During Stage 1, many projects from various funding sources, (ERP, CVPIA/AFRP, and the Wildlife Conservation Board) were implemented to improve fish passage for salmonids in the Sacramento Valley by improving existing facilities, constructing new fish passage and protection facilities, creating exclusion barriers, repairing weirs, and removing physical barriers to upstream and downstream migration. ERP alone has provided over $98 million for screen and passage projects. During Stage 1 ERP Implementation, CALFED and CVPIA focused on completing ongoing projects and maintaining existing investments.

Four projects (in three phases) were funded to enhance the survival of adult salmon returning to spawning habitat between the Anderson-Cottonwood Irrigation District (ACID) diversion dam (near Redding, California) and Keswick Dam on the Sacramento River. This was done by constructing two fish ladders and improving a screen at the ACID dam. Two of the four projects were full-scale implementation projects which included the construction of the fish passage facilities, construction management, mitigation, and monitoring of the new facilities. Installation of the fish screens and ladders reduced entrainment of anadromous fish and promoted unimpaired safe passage for all runs of Chinook salmon, steelhead, and green and white sturgeon.

A significant salmon recovery project within the Sacramento River Region is taking place on Battle Creek. The Battle Creek Salmon and Steelhead Restoration project is the largest coldwater anadromous fish restoration effort in North America. The project will restore approximately 42 miles of Chinook salmon and Central Valley steelhead habitat in Battle Creek (a tributary to the Sacramento River that runs through Shasta and Tehama counties) and will restore six miles of habitat in its tributaries. The project includes the removal of five dams with screens and ladders added to three others. Once the project is completed, flows in Battle Creek will also increase by approximately ten fold in all of the reaches.

Work was completed in 2008 on two new screens in the Cow Creek drainage in an effort to protect juvenile fall and late-fall run Chinook salmon, and steelhead rainbow trout from agricultural diversion ditches. Plans are being developed for at least three more screens and passage structures around three small agricultural diversion dams. Construction of passage structures around these dams will provide access to approximately 30 miles of prime habitat that are currently inaccessible. ERP is currently seeking funds and cooperators for these new passage structures and screens.

Fish passage improvements continue on Clear Creek, a tributary to the Sacramento River. The Clear Creek Restoration Program, funded under several federal and state authorities, has contributed significantly to the increase in spawning escapements of fall-run Chinook in Clear Creek by releasing more water from Whiskeytown Dam to increase flow in the creek, removing McCormick-Saeltzer Dam in the year 2000, supplementing the gravel supply which was blocked by Whiskeytown Dam, implementing methods to control erosion having negative impacts to salmonid habitat, removing stranding sites, and restoring the stream channel. A small but increasing population of spring-run Chinook is now located in Clear Creek, and steelhead populations are also increasing. Additionally, monitoring also provided by CVPIA funds assessed fish stranding at different flow rates, which helped to identify sites requiring passage improvement.

Construction of a new screen structure at Red Bluff Diversion Dam (RBDD) has recently been completed. The dam has been identified by Reclamation, USFWS, NMFS, and CDFW as one of the major causes of the decline in salmon and steelhead in the upper Sacramento River. The purposes of the new screen and associated Red Bluff Pumping Plant (RBPP) project are: 1) to allow for substantial improvement in the long-term ability to reliably pass anadromous fish and other species of concern, both upstream and downstream, through RBDD and 2) to substantially improve the long-term reliability and cost effectiveness of moving water into the Tehama Colusa Canal and Corning Canal systems to meet the needs of the water agencies and farmers served by the Tehama Colusa Canal Authority (TCCA). This project is an exceptional restoration opportunity and is an important step to secure future salmon runs and cooperate with agricultural interests.

The RBPP is the culmination of over 40 years of efforts and includes construction of a new screen and pumping plant near the existing canal headworks with an initial installed capacity of 2,000 cfs and a footprint that will allow expansion to 2,500 cfs. The new pumping plant will allow the gates of the RBDD to remain open all year and provide unimpeded passage for all species and life stages of fish present. RBPP and fish screens will need to be monitored and maintained to ensure the benefits of the project are realized. Fish species benefited include sturgeon, all four runs of Chinook salmon and steelhead. The groundbreaking ceremony occurred on March 23, 2010, and the RBPP and fish screen were completed in August 2012.

While many projects were funded by multiple sources during Stage 1 to address fish passage issues, additional projects are needed in the Sacramento Valley. Projects that either enhance habitat downstream of rim dams or establish additional spawning locations for Chinook salmon and steelhead are needed. Further work is needed on preventing stranding of Chinook salmon redds caused by changes in flow releases at Keswick Dam. This is especially apparent in October after the agricultural irrigation season when flows drop from around 10,000 cfs to 3,500 cfs. Preliminary studies are underway to assess this issue.

IV. Species

ERP Goal 1 (Endangered and Other At-risk Species and Native Biotic Communities) is to initiate recovery of at‐risk native species as the first step toward establishing large, self‐sustaining populations of these species and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed. ERP intends to continue working toward species recovery by focusing on restoring environmental processes, creating suitable habitat areas, and reducing stressors, rather than taking a narrow species-by-species approach to conservation. As stated in the Sacramento-San Joaquin Delta Section, the following discussion is on a small subset of the species targeted by ERP.

Chinook Salmon. As of 2007, the anadromous fish populations in the Central Valley experienced a significant decline, which led to the Pacific Fishery Management Council's (PFMC) recommendation and the NMFS closure of California Chinook salmon fishing (commercial and most recreational) in 2008, 2009, and restricted in 2010. These closures marked the first time in 150 years such drastic measures have been necessary.

Much of what has been learned about the four runs of Chinook salmon (*Oncorhynchus tshawytscha*) (winter, spring, fall, and late-fall), as well as steelhead, is the result of genetic research and management programs that occurred in upstream areas and at hatcheries. Within the Sacramento Valley, ERP-funded projects studied the migration and movement of adult and juvenile Chinook salmon as well as the genetics of anadromous salmonids. These efforts included the following projects:

- Implementation of a Constant Fractional Marking/Tagging Program for Central Valley Hatchery Chinook Salmon;
- Determination of Age Structure and Cohort Reconstruction of Central Valley Chinook Salmon Populations;
- Estimating the Abundance of Sacramento River Juvenile Winter Chinook Salmon with Comparisons to Adult Escapement and;
- Upper Sacramento River Basin Chinook Salmon Escapement Monitoring Program

Annual estimates of fish populations on the Sacramento River are a key ingredient in management to protect fish in the Delta. There is a strong need to understand and reduce the uncertainties in those estimates through more field studies and data analysis, as well as by using advanced field methodologies and modeling capabilities. Models and basic studies that might allow better connection of management of and specific stressors to population responses of key species of native fish are critical to protecting fish and managing water supplies.

The Upper Sacramento River Basin Chinook Salmon Escapement Monitoring Program is an example of an ongoing project that provides annual monitoring of abundance, migration timing, and distribution of adult winter, spring, late-fall, and fall-run Chinook salmon returning to spawn in the Upper Sacramento River Basin. Continuous monitoring is needed to make effective decisions about fisheries management. Data obtained from this project also help achieve ERP goals of recovery of at-risk native species and maintaining and/or enhancing populations of selected species for sustainable commercial and recreational harvest.

There is a need to understand juvenile life history requirements of salmonids, splittail, and delta smelt in the Sacramento River and tributaries. The Clear Creek Juvenile Salmonid Monitoring project provides essential information on the status, trends, and habitat use of juvenile salmonids and the Clear Creek Anadromous Salmonid Monitoring Program provides essential information concerning the status and trends of anadromous salmonids on Clear Creek for all life stages. Information from these projects has informed management decisions and/or recommendations made by the Clear Creek Restoration Team, which is comprised of regulatory agencies, land management agencies, and local government, on restoration projects and future efforts.

Significant differences exist in Chinook salmon and steelhead life histories and environmental requirements. Efforts to better understand these differences and their mechanistic causes and implications are needed. During Stage 1 implementation, life history patterns and stock composition of steelhead in the Yuba River were successfully characterized to support ecosystem restoration and species recovery programs.

Additionally, assessment of the impacts from light sources along the Sacramento River which lead to increased predation on juvenile salmonids is also needed. A notable example is the Sundial Bridge in Redding, which uses numerous floodlights that illuminate the Sacramento River all night, year round. Approximately 80 percent of the winter-run Chinook salmon population in the state spawn upstream of the bridge and the out-migrating juveniles must pass through the lighted portion of the river below the bridge and face predators. Studies in Washington State have found lighted portions of streams have significantly higher predation rates on juvenile fish. Downstream of the Sundial Bridge, there are several other light sources ranging from highway bridges to lighted water intake structures. These should all be evaluated and recommendations should be developed to fix identified problems.

Conservation actions will include coordination of protection, enhancement, and restoration of occupied and historic Central Valley salmon habitats with other federal, state, and regional programs. These efforts will include implementation of measures in the restoration plan for the AFRP, the Central Valley Salmon and Steelhead Recovery Plan and applicable CDFW management measures; appropriate operation of hatcheries such that natural populations are not threatened; management of fish passage to reduce predation on juveniles and increase their survival; improved export flows to improve conditions for upstream migration of adults; and operation of physical barriers consistent with achieving recovery goals.

Steelhead. Steelhead (*O. mykiss*) depend on essentially all habitats of the Sacramento River system: the main channel for migrating between the ocean and upstream spawning and rearing areas and the tributaries for spawning and rearing. The construction of low elevation dams on major tributaries of the Sacramento River has denied steelhead access to most of their historical spawning and rearing habitats in upstream areas. See full write-up in Delta species section.

Conservation actions will include coordination of protection, enhancement, and restoration of occupied and historic Central Valley steelhead habitats with other federal, state, and regional programs; implementation of measures in the restoration plan for the AFRP, the Central Valley Salmon and Steelhead Recovery Plan and applicable CDFW management measures; and the minimization of flow fluctuations to reduce or avoid stranding of juveniles.

Green and White Sturgeon. Sturgeons are native anadromous fish that inhabit both salt water and freshwater and tolerate a wide range of salinity concentrations. Spawning occurs in larger rivers upstream of the Delta. White sturgeon rear in the Sacramento-San Joaquin estuary and spawn in the Sacramento and San Joaquin rivers and their major tributaries. Green sturgeon (*Acipenser medirostris*) are an at-risk species native to the Sacramento River, yet little is known about the habitat needs of this species and its response to restoration. The ERP funded research to conduct telemetric, physiological, reproductive, and genetic studies to provide State and Federal agencies such as the ERP Implementing Agencies with information on the size of the population and its critical habitat within the Sacramento-San Joaquin watershed. This information will inform a recovery plan for the species. The distribution of spawning adults and juveniles will be continuously monitored using automated listening stations situated throughout the Sacramento River as well as the Bay-Delta Estuary.

Conservation efforts will focus on major limiting factors to sturgeon populations, such as inadequate streamflows to attract adults to spawning areas, illegal harvest, and entrainment into water diversions. In addition, food availability, toxic substances, and competition and predation are other factors that influence sturgeon abundance that will be evaluated.

Splittail. It is likely that reproductive success of the splittail (*Pogonichthys macrolepidotus*) is tied to the timing and duration of flooding of the Yolo and Sutter Bypasses and to flooding of riparian zones along the major rivers of the Central Valley. A return to its former abundance and distribution will require special management of these areas. Improvements in the riparian and stream meander corridors along the Sacramento River will improve spawning and early rearing habitat of splittail. Late-winter and early spring streamflow improvements will provide attraction flows for spawning adults and increased spawning habitat.

Conservation for splittail will include coordination of protection, enhancement, and restoration of occupied and historic splittail habitats with other, federal, state, and regional programs. These actions will include removal of diversion dams that block access to lower floodplain river spawning areas, designing of seasonal wetlands hydrologically connected to channels, changes in timing and volume of freshwater flows, improvements in Delta water facility operations and water quality, screening of unscreened Delta diversions, management of harvest activities, setting back levees to increase shallow water habitat, and reduced extent of reversed flows in the lower San Joaquin River and Delta during February through June.

Lamprey. In California, river lampreys (*Lampetra ayresi*) are known to be extirpated from Cache Creek (P. Moyle, pers. comm. 2004). The western brook lamprey has been observed primarily in the Sacramento River drainage (Moyle 2002), but has also been reported in San Francisco Bay streams such as Mark West Creek and Coyote Creek (Moyle 2002).

Conservation actions will align with the existing Pacific Lamprey Conservation Initiative (PLCI), a USFWS strategy to improve the status of Pacific lampreys by proactively engaging in a concerted conservation effort. The resulting collaborative conservation effort, including the State of California, will facilitate opportunities to address threats, restore habitat, increase our knowledge of Pacific lamprey, and improve their distribution and abundance. The PLCI seeks to improve the status of Pacific lamprey by coordinating conservation efforts among states, tribes, federal agencies, and other involved parties.

Sacramento Perch. Sacramento perch (*Archoplites interruptus*) populations have declined throughout their native range that included the Sacramento River Region.

Possible reasons for the Sacramento perch's decline include loss of habitat, competition with non-native species, and egg predation (USFWS 1995a).

Other At-Risk Species. While many of the ERP activities in the Delta and its watershed focus on fish and aquatic resources, the ERP also provides funding to numerous studies, land acquisitions, and habitat creation efforts designed to benefit terrestrial species and plant communities. These others species were specifically identified in ERPP and MSCS documents and their associated descriptions, actions, targets and desired outcomes in those documents are incorporated by reference in this document. The following provides a focused list of other at risk species but should in no way be construed to limit ERP's conservation focus to a level different than that identified in those earlier documents.

The following provides a focused list of other at risk species but should in no way be construed to limit ERP's conservation focus to a level different than that identified in the earlier ERPP and MSCS documents.

Black Rail. Historically, the black rail (*Laterallus jamaicensis coturniculus*), occurred in saline and brackish emergent wetlands in the San Francisco Bay, coastal Marin County, coastal wetlands of southern California, and isolated interior areas of southern California (Grinnell and Miller 1944). More recently California black rails have been found in 164 small, widely scattered marshes distributed along the lower western slopes of the Sierra Nevada foothills from just northeast of Chico (Butte County) to Rocklin (Placer County) (Richmond et al. 2008). Creation of habitat for the black rail is being considered in restoration plans and floodplain acquisitions.

Greater Sandhill Crane. The greater sandhill crane (*Grus Canadensis tabida*) is found throughout most of the Central Valley in winter and nests in northeastern California and Oregon. Habitats used include seasonal and fresh emergent wetlands, grasslands, and agricultural lands. Much of their nesting habitat has been lost due to conversion to agricultural lands and intensive cattle grazing.

Conservation efforts will include implementation of actions in concert with species recovery strategies, including the enhancement of agricultural habitat to improve the abundance and availability of upland agricultural forage (e.g., corn and winter wheat). The restoration of wetlands should give priority to restoring and managing wetland habitat within areas that provide suitable roosting habitat and recreational uses should be avoided or minimized in areas that could disrupt crane habitat use patterns from October-March. A portion of enhanced agricultural lands should be managed to increase forage abundance and availability for cranes and monitoring efforts to determine their use of protected, restored and enhanced habitats in core wintering areas should be completed.

Tricolored Blackbird**.** The Tricolored Blackbird (*Agelaius tricolor)* is North America's most colonial landbird. Its breeding colonies often teem with more than 50,000 birds, sometimes all settled into a single 10-acre field or wetland to raise their young. Over just the last 70 years, the Tricolored Blackbird population has decreased by more than 80%.

Conservation efforts include habitat conservation, research to more thoroughly understand the species' life history, monitoring to document population trends and distribution, and education to enhance public and private landowner awareness and support for conservation efforts.

***Waterfowl*.** California has lost more than 95% of its historic wetlands, largely due to urbanization, flood control and agriculture. As a result, many species have declined from historic levels, and are increasingly dependent on fewer wetlands. Despite these tremendous habitat losses, the Central Valley of California is the most important waterfowl wintering area in the Pacific Flyway, supporting up to 60% of the total Flyway population in some years (Heitmeyer 1989) and higher proportions of certain populations. Food availability is a key factor limiting waterfowl populations during migration and winter (Miller 1986, Conroy et al. 1989, Reinecke et al. 1989), and habitat conditions on the wintering grounds may influence reproductive success (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987, Raveling and Heitmeyer 1989).

ERP supports action to maintain and restore healthy populations of waterfowl at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Conservation actions will include improved seasonal wetlands and floodplain/stream interactions.

Neotropical Migratory Birds. Many of the ERP-funded restoration projects that include riparian restoration have collected information on restoration success; however additional scientific studies are needed to determine appropriate conditions for the germination and establishment of riparian woody plants along the Sacramento River. On lower Clear Creek, riparian habitat monitoring and Neotropical migratory bird monitoring is providing information on how to adaptively manage for and design future restoration projects. Because such a limited amount of riparian habitat remains, compared to historical conditions, certain populations of Neotropical migratory birds, such as yellow warbler, bank swallow, and yellow-billed cuckoo, are in danger of extirpation from the valley floor due to a combination of habitat fragmentation and/or loss, predation, parasitism, and contaminants. Implementation of riparian habitat Stage 2 conservation priorities are needed to protect these species and others similarly affected.

***Bank Swallow*.** The bank swallow (*Riparia riparia*) was once considered to be common throughout California. Today, bank swallows are locally common only in certain restricted portions of their historic range where sandy, vertical bluffs or riverbanks are available for these colonial birds to construct their nest burrows. The bank swallow nests in earthen banks and bluffs, as well as sand and gravel pits. It is primarily a riparian species throughout its North American and Eurasian breeding range.

Conservation efforts will continue to coordinate protection and restoration of channel meander belts and existing bank swallow colonies with other federal and state programs (e.g., participation in planning and implementation of activities associated with the Army Corps of Engineers Sacramento and San Joaquin Basin levee efforts and The Riparian Habitat Joint Venture) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. Proposed ERP actions designed to protect or restore stream meander belts should initially be implemented along reaches of the Sacramento River and its tributaries that support nesting colonies or potential nesting habitat. Monitoring should also occur to determine the response of bank swallows to restoration of stream meander belts and riparian habitat. Coordinate with Reclamation and DWR to phase spring-summer reservoir releases in a manner that would reduce the potential for adverse effects on nesting colonies that could result from large, pulsed, releases.

***Calfornia Yellow Warbler*.** The California yellow warbler (*Dendroica petechia*) summers throughout northern California and in the coastal regions of southern California. In recent decades, there has been a marked decline in the breeding population of these birds in both the San Joaquin and Sacramento valleys. Loss of riparian habitat from agricultural and urban development, and brood parasitism by brown-headed cowbirds are believed to contribute to the decline of this species.

Conservation efforts will coordinate protection and restoration of riparian habitat with other federal and state programs that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. As possible, actions will protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat. A portion of restored riparian habitat area will be designed to include riparian scrub communities and, in associated with implementing ERP's wildlife friendly agriculture program, work with farmers to reestablish native trees, shrubs, grasses and wildflowers on their field edges. As practicable, restore riparian habitats in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

Swainson's Hawk. Swainson's hawks (*Buteo swainsoni*) are not an obligate riparian species, in the Sacramento Valley, its dependency on the availability and distribution of large nesting trees that are close to high-quality foraging habitats results in a preference for riparian forests. Additionally, the agricultural landscape nearest most of the Sacramento Valley riparian forests is a mix of crops, irrigated pasture, seasonal wetlands and uncultivated grassland habitats, very good foraging areas for this hawk.

Conservation actions will focus on the restoration of valley/foothill riparian habitat initially in the Delta. Seasonal wetlands will be designed into occupied habitat areas to provide overwinter refuge for rodents to provide source prey populations during spring and summer. Actions will include a percentage of agricultural lands to be enhanced under the ERP in the Delta, Sacramento River, and San Joaquin River Regions to increase forage abundance and availability within 10 miles of occupied habitat areas. Efforts will manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels. As practical, actions will manage restored or enhanced habitats under the ERP to maintain desirable rodent populations and minimize potential impacts associated with rodent control.

Yellow-billed Cuckoo. In California's Central Valley, the western yellow-billed cuckoo (*Coccyzus americanus*) depends on riparian vegetation for cover, foraging, and breeding (RHJV 2000). Within riparian vegetation, dense, low, shrubby vegetation is a particularly important habitat component (Dunn and Garrett 1997, Brown 1993, RHJV 2000). In addition, landscape attributes such as patch size and surrounding land uses affect western yellow-billed cuckoo populations. Populations of western yellow-billed cuckoo persist best in large blocks of riparian forest (20–80 ha and often more than 300 ft wide) of meandering riparian zones (Halterman 1991).

Conservation efforts will continue to coordinate protection restoration and enhancement of large, contiguous areas of riparian and wetland habitat with other federal and state programs that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. These habitat areas should maintain a great diversity in composition, density and make-up. As possible, actions will protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat. A portion of restored riparian habitat area will be designed to include riparian scrub communities and, associated with implementing ERP's wildlife friendly agriculture program, work with farmers to reestablish native trees, shrubs, grasses and wildflowers on their field edges. As practicable, restoration of riparian habitats will be in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds. Actions will restore large contiguous blocks of suitable valley/foothill riparian forest and woodland at least 200 meters in width and 500 acres in size along reaches of the Sacramento River adjacent to occupied habitat areas (Red Bluff to Chico).

California Red-legged Frog. The California red-legged frog (*Rana draytonii*) historically occurred throughout the Central Valley and now exists only in small isolated populations scattered throughout its historical range. Major factors for the decline of the California red-legged frog include degradation and loss of critical wetland breeding habitat and adjacent terrestrial habitats. Stressors from human activities like agricultural practices (disking, mowing, burning, and pest control) also contribute to the population decline. Restoration of suitable aquatic, wetland, and riparian habitats and reduced mortality from predators will be critical to achieving recovery of the California red-legged frog.

Conservation measures will protect, restore, and enhance suitable aquatic, wetland, and riparian and upland habitats that will benefit the recovery of the red-legged frog.

Efforts to manage invasive species such as the bullfrog will also be carried out where necessary to benefit the recovery of the species.

***Foothill Yellow-legged Frog*.** The foothill yellow-legged frog (*Rana boylii)* has disappeared from much of its range in California (possibly up to 45 percent). Water released from reservoirs, that washes away eggs and tadpoles and forces adult frogs away from the streams leaving them more vulnerable to predators, is a serious problem for frogs in the Sierra Nevada foothills. Air-borne pesticides from the vast agricultural fields of the Central Valley are also likely to be a primary threat. Recreational activities along streams that alter streambeds, especially gold mining, are also having a negative impact on frog populations in the Sierra foothills. Introduced fish also stress frog populations by consuming eggs and tadpoles, and introduced bullfrogs compete for food and eat the frogs. Habitat loss, disease, introduced crayfish, stream alteration from dams, mining, logging, and grazing, are also threats to this frog.

Conservation measures will protect, restore, and enhance suitable aquatic, wetland, riparian and upland habitats that will benefit the recovery of the species; and feasible actions will be implemented to address concerns with disease, introductions of non-native trout, airborne contaminants, wildland fires, fire suppression activities, climate change, livestock grazing, water developments, and recreational activities. Efforts to manage invasive species such as the bullfrog will also be carried out where necessary to benefit the recovery of the species.

***California Tiger Salamander*.** The California tiger salamander (*Ambystoma californiense*) uses burrows for aestivation and shelter during the warm, dry months of summer and autumn. Because California tiger salamanders dig poorly, the burrows of small mammals are essential. Their habitat is usually within grassland or oak savannah, and sometimes oak woodland.

Conservation actions will maintain existing populations in the Bay-Delta, protect and restore existing and additional suitable aquatic, wetland, and floodplain habitats and reduce the effect of other factors that can suppress breeding success.

***Western Spadefoot Toad*.** Optimal habitat for the western spadefoot toad (*Spea hammondii*) is grasslands with shallow temporary pools. Western spadefoot toads are rarely found on the surface as most of the year is spent in underground burrows up to 0.9 m (36 in) deep (Stebbins 1972), which they construct themselves. Breeding and egg laying occur almost exclusively in shallow, temporary pools formed by heavy winter rains. During dry periods, the moist soil inside burrows provides water for absorption through the skin (Ruibal et al. 1969, Shoemaker et al. 1969). Dispersal of post-metamorphic juveniles from breeding ponds often occurs without rainfall.

Conservation actions will maintain the species in the Bay-Delta by protecting and restoring existing and enhancing additional suitable aquatic, wetland, and floodplain habitats; and by reducing the effect of other factors that can suppress breeding success. To stabilize and increase its population, efforts will focus on the elimination of non-native predator species from historic habitat ranges. Additionally, actions will increase suitable habitat and maintain clean water supplies to meet the needs of this species.

Giant Garter Snake. Populations of giant garter snake (*Thamnophis gigas*) are found throughout much of the Focus Area, including portions of the Sacramento Valley (CALFED 2000a). Improvements to and maintenance of suitable agricultural infrastructure (e.g., ditches, drains, canals, levees) as part of the ERP conservation priorities to enhance wildlife habitat values associated with agricultural lands may be important because giant garter snake has had to adapt to using these artificial features (CALFED 2000a).

Conservation actions will restore wetland and upland habitats adjacent and connected to occupied habitat. Actions will restore fresh emergent wetland habitat adjacent to and connected with existing non-tidal emergent wetlands already used by giant garter snake, providing essential forage habitat and refuge from predators and frequent flood events, and creating dispersal corridors by linking habitat areas. The restoration of aquatic, wetland, riparian, and upland habitats in the Butte Basin will help in the recovery of this species by increasing habitat quality and area.

Western Pond Turtle. The western pond turtle (*Clemmys marmorata*) originally ranged from northern Baja California, Mexico, north to the Puget Sound region of Washington. They occur in both permanent and intermittent waters, including marshes, streams, rivers, ponds and lakes, favoring habitats with large numbers of emergent logs or boulders where they aggregate to bask.

Conservation action includes maintaining and expanding the abundance and distribution of *C. marmorata* by maintaining or expanding its existing populations by improving stream channel, floodplain riparian processes, and reducing predator species.

Valley Elderberry Longhorn Beetle. The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) (VELB) is a federally listed threatened species. Presumably, its populations will respond positively to riparian restoration projects that maintain and restore connectivity among riparian habitats occupied by the VELB within its historical range along the Sacramento Rivers and its major tributaries

Conservation actions will focus on riparian restoration projects that maintain and restore connectivity among riparian habitats occupied by the VELB within its historical range in the Delta and along the Sacramento and San Joaquin Rivers and their major tributaries.

Vernal Pool Species. Vernal pools are seasonally flooded depressions found on ancient soils with an impermeable layer such as a hardpan, claypan, or volcanic basalt. The impermeable layer allows the pools to retain water much longer then the surrounding uplands; nonetheless, the pools are shallow enough to dry up each season. Vernal pools often fill and empty several times during the rainy season. Only plants and animals that are adapted to this cycle of wetting and drying can survive in vernal pools over time. Many of these are native species endemic to vernal pools or related wetland habitat.

Conservation actions for vernal pool species will include ERP actions directed towards protecting, enhancing, and restoring suitable vernal pool and associated grassland habitat within these species historic ranges. ERP actions will coordinate these actions with other federal and state programs to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. Conservation effort will conduct surveys to identify suitable habitat areas and enhance and restored habitats for establishment of additional populations of vernal pool species in the Delta and its watershed, and implement species introductions to establish additional populations as appropriate. Lands will be appropriately maintained when purchased or acquired under conservation easements that are occupied by vernal pool species to maintain or increase current population levels and enhance occupied habitat areas.

SECTION 3: San Joaquin Valley Region

Background

Composed of the southern half of California's Central Valley, the 290-mile-long San Joaquin River Valley is bounded on the west by the Coast Ranges and on the east by the Sierra Nevada. The San Joaquin River Valley has an average width of 130 miles and contains two distinct hydrologic basins, the San Joaquin Basin in the north, and the Tulare Lake Basin in the south. Often, during wet years, the Tulare Lake Basin contributes flood-flows to the San Joaquin River through the North Fork of the Kings River and the Fresno Slough. In general, the San Joaquin River flows west from the Sierra Nevada, turns sharply north at the center of the valley floor, and flows north toward the Sacramento-San Joaquin Delta. The San Joaquin River drains more than 14,000 square miles in total.

The west slope of the Sierra Nevada drains into many streams and three major rivers on the east side of the San Joaquin Valley and then flows into the San Joaquin River. The major eastside tributaries are the Stanislaus, Tuolumne, and Merced rivers. Streams located south of the Merced River include Bear Creek and the Chowchilla, Fresno, and upper San Joaquin rivers. The east slope of the Coastal Range drains into a few relatively small intermittent streams on the arid west side of the San Joaquin Valley, but these flows rarely reach the San Joaquin River. In addition to natural runoff, there are several westside sloughs that contain flows augmented by agricultural drainage and spill flows.

Snowmelt runoff from the Sierra Nevadas is the major source of water to the San Joaquin River and the larger eastside tributaries. Due to this snowmelt, historical peak flows were in May and June, with natural overbank flooding taking place in many years along all the major tributaries and the mainstem. This overbank flooding historically created several hundred thousand acres of permanent tule marsh, and more than 1.5 million acres of seasonally flooded wetlands and native grasslands. In addition, the system had natural levees and upper floodplains of rich alluvial soils that once supported as much as two million acres of large, diverse riparian forests. As the elevation above the channel increased, the riparian zone graded into higher floodplains supporting valley oak and native grasslands interspersed with vernal pools.

Historically, the San Joaquin River spring-run Chinook salmon was the most abundant run in the Central Valley. They were present on every major tributary and stream in the San Joaquin River Basin. Smaller populations of steelhead, and fall-run salmon occurred as well (Fry 1961). The CDFW estimates pre-gold rush era spring-run salmon populations in the San Joaquin River numbered between 200,000 and 500,000 annually, with the combined runs of the Merced, Stanislaus, and Tuolumne rivers also contributing as many as 200,000 spring-run salmon in some years (Moyle 2002).

Agricultural development in the San Joaquin Valley brought dramatic changes in the hydrologic system and surrounding ecosystems. Beginning in the 1850s, water and land development changed the natural streamflow pattern of the San Joaquin River and its tributaries. The once high spring flows were now captured in water storage and hydro-electric project reservoirs. Only the years with highest precipitation provided the dynamic flood flows necessary to maintain native downsteam habitats. Upland changes included widespread conversion of natural habitats with less than 10 percent of the historical wetland acreage and less than 2 percent of the historical riparian acreage currently remaining as remnant vestiges.

Anandromus fish populations within the San Joaquin Valley continue to dramatically decline. Annual escapement (fish that survive migration to spawn) of fall-run Chinook salmon has been estimated since 1940, but is poorly documented prior to 1952. Data from 1952 to present suggests that major San Joaquin River tributary fall-run boom and near-bust cycles have existed for at least the last 80 years. The California Fish and Game Commission noted as early as 1884 that salmon had been negatively affected by dams on the Stanislaus, Tuolumne, and the San Joaquin rivers. With the onset of gold mining and its associated changes to hydrology and water quality, populations of Chinook salmon began to diminish further. Dams and their associated reservoirs also serve as migration barriers to adult salmon, preventing access to as much as 72 percent of the Central Valley's historical salmon and steelhead spawning and holding habitat (Yoshiyama et al. 1996). In 1928, CDFW issued a bulletin reporting that very few salmon remained in the San Joaquin River above the confluence of the Merced River due to increased water diversions and the operation of upstream hydropower reservoirs (NMFS 2009b). Over time, as increased infrastructure and water demand further altered the San Joaquin River Basin, Chinook salmon populations declined further, some to extirpation.

The southernmost stocks of San Joaquin River spring-run and fall-run Chinook salmon and steelhead upstream of the confluence with the Merced River were completely eliminated. Although spring-run Chinook salmon were probably more abundant pre-disturbance (ranging from 2,000 and 56,000 between 1943 and 1948) (DFG 1993), based on the habitat and hydrology of the San Joaquin River Basin (Williams 2006), they were the first to be extirpated in the 1950s when Friant Dam and all of the diversions became fully operational, which restricted access to the upper watershed and limited flows downstream of the dam. The remaining fall-run Chinook, thought to already be limited to about 1,000 spawning adults in the 1940s, was also eliminated by the dam's dewatering of the San Joaquin River over succeeding decades. Streamflow releases to the San Joaquin River below the dam are now insufficient to support salmon passage, spawning, or rearing. Typically 60 miles of the San Joaquin River are dry, including Gravelly Ford to the Mendota Pool reach except during extremely high runoff periods.

Due to the negative effects on Chinook salmon by Friant Dam, several legal actions were taken that resulted in the San Joaquin River Settlement Agreement of 2006 (Settlement) and the creation of the San Joaquin River Restoration Program (SJRRP), which is a multi-agency effort to implement the Settlement. The Settlement provides for increased flows from Friant Dam to the confluence of the Merced River, restoration of portions of the river channel, and the goal to restore and maintain viable fish populations in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River (Revive the San Joaquin 2011).

CDFW released recommendations on biological objectives and flow criteria for species in the Delta (DFG 2010b). The document recommends San Joaquin River outflows that support fall juvenile salmon migration by mimicking the natural hydrograph during winter and spring (these flows may differ from those outlined in the Settlement mentioned above). For the San Joaquin River Basin and eastside tributaries, the recommendations are to provide sufficient water flow depending on year type to transport salmon smolts through the Delta in order to contribute to the attainment of the salmon protection water quality objective of doubling the natural production of Chinook salmon from the average production of 1967-1991.

Not all the changes to hydrology result from a reduction in water. Downstream of the Merced River confluence, summer and fall flows are higher than historical flows in order to provide water for irrigation and urban water supply, but these flows are not always contained within the important river channel reaches which are important to juvenile salmonids. For the mainstem, the CVP brings water from the Sacramento River and re-waters a portion of the San Joaquin River in the summer and fall between the Mendota Pool and Sack Dam. This reach is normally dry due to diversion of most of the mainstem San Joaquin River water at Friant Dam to the Tulare Lake Basin.

In recent years, fall-run Chinook spawning escapements in the San Joaquin River Basin have declined to alarmingly low levels. In fall 1991, an estimated 658 fish returned to the basin to spawn, compared to 135,000 in 1944; 80,500 in 1953; 531,400 in 1960; and 70,000 in 1985. Lower fall attraction flows and spring outflows on the mainstem San Joaquin River reduced adult returns, production, and survival of salmon throughout the system. When spring outflow at Vernalis is high, the total adult salmon escapement in the San Joaquin River Basin increases 2.5 years later (DFG 2010a).

I. Ecosystem Processes

Ecological processes act directly, indirectly, or in combination, to shape and form the ecosystem. The ERP Goal 2 (Ecological Processes) is to rehabilitate natural processes to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities. The most notable processes affecting conditions in the San Joaquin River Basin are: hydrodynamics and hydraulics, including the amount of flow entering the Delta from rivers and tributaries and the movement of water affected by ocean tides, channel geometry, diversions, and barriers; channel-forming processes, including floodplain connectivity and inundation and coarse sediment supply; and freshwater flows. In addition, poor water quality, elevated water temperature, and diminished or altered food web create stresses on the system.

San Joaquin Valley Streamflows. In rivers and streams, flow affects depth and habitat continuity, including access to spawning and rearing areas, and floodplain and secondary channels – with all corridors providing connectivity. In addition, flow magnitude and duration affects geomorphic processes (e.g., maintenance and recruitment of spawning gravel, recruitment of woody material, variable channel geometry and pattern); riparian processes (e.g., establishment and maintenance of riparian vegetation); flow depth over redds; prey production and availability; larval transport; water temperature, contaminant concentration; predation; and entrainment in diversions. Inadequate instream flows may have an effect on all life stages of Chinook salmon and steelhead.

Low streamflow affects gravel recruitment, spawning, and incubation by reducing the area of usable spawning gravel. Suitable spawning gravel should be covered by flow at least 0.8 ft deep and with velocities between 0.8 and 3.8 ft/sec (Bjornn and Reiser 1991, Raleigh et al. 1986). Reduced flow during the period of incubation could cause mortality through desiccation of redds or reduced circulation that results in low DO accumulation of metabolic waste, and increased incidence of disease.

The rearing capacity of a stream is also affected by low streamflows. Predation may increase during low flow, particularly during downstream migration of juveniles. Higher flows result in faster outmigration, reduced water clarity, and cooler water temperature, all contributing to a reduction in predation by non-native predators such as centrarchids and striped bass (USFWS 1996). For juvenile salmonids, both flow and depth affect travel time. Faster travel time may reduce exposure to predation and facilitate movement of smolts to the ocean (Berggren and Filardo 1993).

Extensive research has been conducted into the complex interaction of multiple life stage factors for anadromous salmonids and the influence of those factors upon salmonid abundance and distribution in the San Joaquin River and its tributaries. The single most significant impact of river operations affecting the anadromous fish populations is the manipulation of flows on the tributaries and mainstem San Joaquin River. Interim actions to assist in recovery of fall-run Chinook and Central Valley steelhead are warranted.

Changes in system geometry (e.g., setback levees, marsh restoration, flooding of islands, etc.) and river inputs must be considered together. The flow regime (i.e., magnitude, frequency, duration, timing, and rate of change of flows) is widely viewed as being of central importance in sustaining the ecological integrity of aquatic ecosystems (Poff et al. 1997, Richter et al. 1996). The flow regime affects water quality, food resources, physical habitat, and biotic interactions and therefore is a primary determinant of the structure and function of aquatic ecosystems (Figure 5) (Poff et al. 1997, Poff et al. 2010).

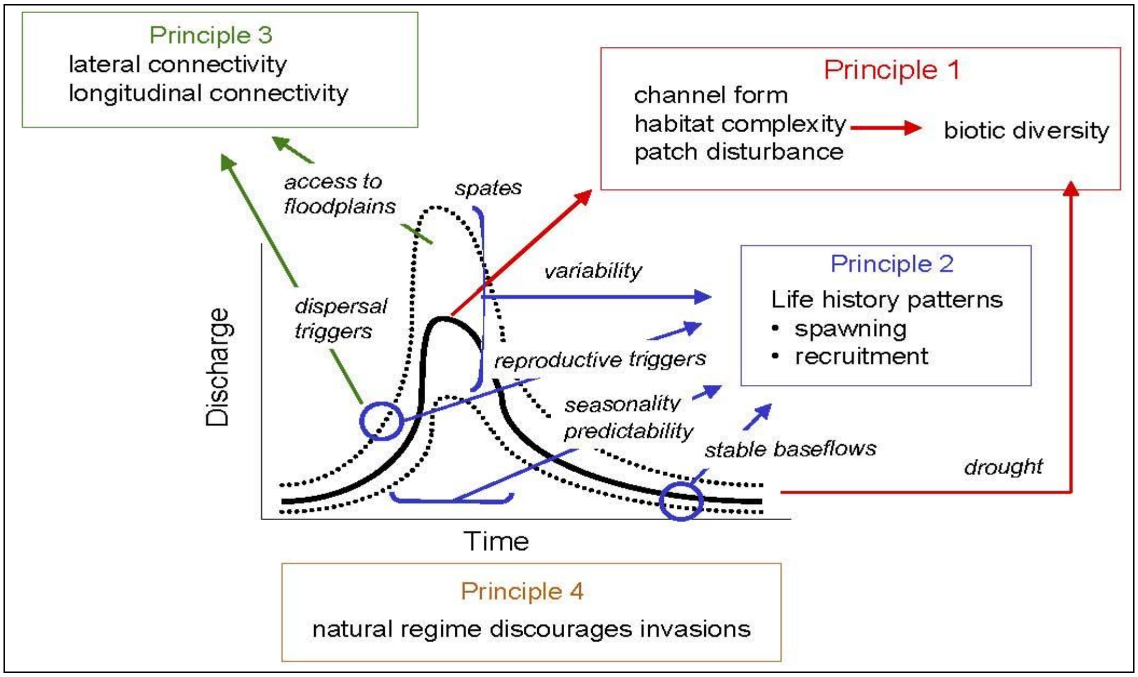

Figure 5: The natural flow regime of a river influences aquatic biodiversity via several, interrelated mechanisms that operate over different spatial and temporal scales. (Bunn and Arthington 2002)

The San Joaquin River and the South Delta are not independent parts or separate systems; they are inextricably linked. Flows from the San Joaquin River are the primary pathway for these ecological services and their value to the rest of the system varies through the year and between years. The San Joaquin River tributaries comprise 68 percent of flow at Vernalis for observed flows from 1984-2009. It is important to also recognize that in drier years the San Joaquin River tributary flow contribution to flow at Vernalis can exceed 80 percent (DFG 2005), and that flows out of San Joaquin River tributaries can be controlled to meet flow targets at Vernalis as documented by the studies conducted under the Vernalis Adaptive Management Program (VAMP) between 2000 and 2010.

Given the extensive water storage and diversion that has occurred in the San Joaquin River Basin, there is both across-tributary and within-tributary flow comparisons that should be made to inform the public of the flow imbalance that has accrued over time. For a cross-tributary comparison, the Tuolumne River watershed is the largest of the three primary watersheds in the San Joaquin River Basin still supporting anadromous fish populations (i.e., Merced, Tuolumne, and Stanislaus rivers). However, it is releasing the least amount of water on a proportional (or ecological fair share) basis. Historically, there were some years when the Tuolumne River had the greatest numbers of fall-run Chinook salmon next to the mainstem Sacramento River (DFG 2009a, Yoshiyama et al, 2001), and also has the widest fluctuation in adult population abundance over time. Given that flow has been shown to have a strong association with adult abundance in the Tuolumne River (DFG 2010b), and the Tuolumne has consistently been releasing the least amount of water proportionately across years, there is great potential restoration for fall-run Chinook in this tributary. This can be accomplished by allowing for more water to consistently be released across years during key fall-run production time periods (e.g., spring).

San Joaquin Valley Stream Temperatures. The operation of reservoirs and discharge from them alters the magnitude, timing, duration, and frequency of suitable water temperatures for fish in downstream reaches and the Delta. Warmer temperatures can have a negative effect on adult migration, spawning and incubation, rearing, and juvenile migration. Warm temperature delays spawning and increases metabolism, causing higher oxygen demand in redds that in turn may result in greater susceptibility to disease (DFG 1991). During downstream migration of salmonids, it may hinder smoltification. The survival of juvenile Chinook salmon in the Delta increases with cooler water temperature conditions (Newman and Rice 1997). Warmer water temperature also limits life history diversity of populations because it abbreviates periods that support migration, spawning, and rearing. Table 2 provides the US EPA recommended temperature thresholds for salmon and trout.

Table 2: US EPA temperature thresholds for Pacific migratory salmonid species and life stages (EPA 2003).

Salmonid Life History Phase Terminology	**US EPA-based Recommended Temperature Thresholds to Protect Salmon and Trout** (Criteria are based on the 7-day average of the daily maximum values)
Adult migration	<64°F (<18°C) for salmon and trout migration
	<68°F (<20°C) for salmon and trout migration - generally in the lower part of river basins that likely reach this temperature naturally, if there are cold-water refugia available
Incubation	<55°F (<13°C) for salmon and trout spawning, egg incubation, and fry emergence
Juvenile rearing (early year)	<61°F (<16°C) for salmon “core” juvenile rearing - generally in the mid- to upper part of river basins
Smoltification	<59°F (<15°C) for salmon smoltification
	<57°F (<14°C) for steelhead smoltification (for composite criteria steelhead conditions are applied)
Juvenile rearing (late year)	<64°F (<18°C) for juvenile salmon and steelhead migration plus non-Core Juvenile Rearing - generally in the lower part of river basins

In the San Joaquin Basin, water temperature in the San Joaquin, Stanislaus, Tuolumne, and Merced rivers is affected by the operations of Friant Dam, New Melones and New Don Pedro Reservoirs and New Exchequer Dam, respectively. Late spring, summer, and early fall water temperature is dependent on temperature of the reservoir releases and the magnitude of flow discharged from the reservoirs. Water temperature in these tributaries generally exceeds 56ºF (13.3ºC) from early June to November on the spawning grounds.

Water temperature on the San Joaquin River is affected by reservoir operations, water diversions, and ambient air temperature. Water temperatures in the San Joaquin River mainstem between the Merced River confluence and Vernalis in the fall and spring often exceed stressful or lethal levels for upstream and downstream migrating fall-run Chinook salmon (CALFED 2000b). CDFW Exhibit 15 to the SWRCB for Phase I of the Bay-Delta hearings showed that, in years when the flow at Vernalis was 5,000 cfs or less in May, water temperatures were at levels of chronic stress for Chinook smolt (DFG 1993).

Water temperature in the San Joaquin River and its tributaries could be improved by modifying the operations of reservoirs to decrease temperature within the reservoir or increase instream flow, maintaining and restoring riparian vegetation, and decreasing warm-water inputs. Reservoir operation improvements could include increasing the minimum pool size and the amount of storage dedicated for temperature control in reservoirs, thus increasing the possibility of providing cooler water in the fall and spring; modifying flow-release schedules; and enhancing flows. In addition, in New Melones Reservoir on the Stanislaus River, temperature control could be provided by installing a temperature curtain or removing Old Melones Dam, located within the reservoir (DFG 1993).

Management of storage and releases from New Melones, Don Pedro, and Lake McClure reservoirs could extend the duration of cool temperature that supports spawning and egg survival, especially for eggs spawned late in the fall that would incubate into the spring when water temperature is warming. Cooler spring water temperature would also increase the duration for support of rearing, allowing fry to spend more time in the river, grow to a larger size, and thus become less susceptible to predation. Optimal water temperatures for growth of salmonids correspond to water temperatures that decrease predation by non-native fish (Rice et al 1983).

Like Chinook salmon, steelhead smolt transformation requires cool temperatures, and successful transformation occurs at temperatures ranging from 42.8ºF to 50ºF (6ºC to 10ºC). Water temperature warmer than 55.4ºF (13ºC) appears to prevent the smolting process (McCullough 1999). Zaug and Wagner (1973 in McCullough 1999) found that steelhead require temperatures cooler than 55.4ºF (13ºC) to successfully complete smolt transformation. When temperature exceeded 55.4ºF (13ºC), the smoltification process was reversed and juveniles lost the ability to migrate. However, as with Chinook salmon, juvenile steelhead migrate through the Delta when water temperature exceeds 68ºF to 72º F (20ºC to 22.2ºC).

Warm water temperature may be detrimental to annual production when a large proportion of the population experiences repeated exposure, increasing vulnerability to disease, high rates of predation by non-native fish species, and reduced survival during spawning, incubation, rearing, and migration (Sullivan et al. 2000, Myrick and Cech 2001).

Agricultural return flows may affect Chinook salmon and steelhead by exposing them to high water temperature, contaminants such as selenium and boron among others, and increasing the risk of straying into sloughs and irrigation canals where there is no suitable spawning or rearing habitat (CALFED 2000b). However, impacts of irrigation return flow depend on the volume of the flow relative to the receiving body of water and the temperature of the receiving water body.

Although steelhead and Chinook salmon in the San Joaquin, Stanislaus, Tuolumne, and Merced rivers could benefit from improved water temperature conditions, the population response is currently uncertain. The ERP Implementing Agencies continue to believe that one critical factor limiting anadromous salmon and steelhead population abundance in the San Joaquin Basin is the high water temperatures that exist during critical life stages in the east-side tributaries and the mainstem of the San Joaquin River. Elevated water temperatures continue to appear to be a factor in the continued decline in adult salmon escapement abundance in the rivers, either by:

- Inducing adult mortality as adults migrate into the San Joaquin River, and tributaries, to spawn (i.e., pre-spawn mortality),
- Reducing egg viability for eggs deposited in stream gravels,
- Increasing stress levels and therefore reducing survival of juveniles within the tributary nursery habitats, or
- Reducing salmon smolt out-migration survival as smolts leave the nursery habitats within tributaries to migrate down the San Joaquin River to Vernalis and through the south Delta.

Other factors may limit survival and production of each life stage, including passage conditions, the quantity and quality of spawning gravel, rearing habitat and food availability, and downstream and Delta conditions.

For rainbow trout and steelhead, excessively warm water temperatures have the potential to limit population abundance by restricting juvenile and adult resident over-summer rearing habitat to very short stream reaches, due to downstream thermal regimes. As such, too few miles of suitable habitat may exist to sustain healthy population levels. Increased water temperatures result largely from reduced instream flows, blockage of water flows (dams), water diversions, hydroelectric power operations, and other water operations.

In 2007, CDFW submitted a water temperature impairment proposal in response to the Central Valley Region Water Quality Control Board's solicitation for water quality data and information for impairments to water bodies as part of their updating of the Clean Water Act 303(d) list of impaired water bodies. CDFW submitted information showing that water temperatures are too warm for reproductive success and recruitment of anadromous fish in the lower San Joaquin River and its tributaries, the Merced, Stanislaus, and Tuolumne rivers. The Central Valley Regional Water Quality Control Board approved the listing of these rivers as temperature impaired and forwarded their recommendations to the SWRCB for review and approval. While the SWRCB did not approve the listing of these water bodies as temperature impaired, the US EPA included them on its list of impaired bodies for California and has reconsidered including the San

Joaquin tributaries as impaired for temperature. CDFW has submitted an updated temperature impairment report (DFG 2010c) for the purpose of listing the San Joaquin River and its tributaries as impaired in the 2012 Integrated Report (CWA 303(d) list/305(b)).

Floodplains and Flood Processes. Flows that exceed the channel conveyance capacity inundate the floodplain. Floodplain inundation deposits sediment on the floodplain, facilitates establishment of riparian vegetation, and provides habitat and other likely benefits including additional food resources for fish. Many native fish and wildlife species are dependent on or benefit from inundated floodplains. The floodplain of the San Joaquin River has been greatly reduced compared to its historical extent (CALFED 2000b). From the Chowchilla Bypass to Mendota Dam, berms and levees locally constrain the river and minimize the area of inundated floodplain. In addition, riparian forests have declined by more than 50 percent and riparian scrub by more than 80 percent from 1937 to 1993 (Jones & Stokes 1998). This loss of inundated floodplain and riparian vegetation contributes to a loss of habitat along this section of the San Joaquin River.

Floodplain habitat is important to the life cycles of many listed species in the San Joaquin Valley. Several target bird species, including the California yellow warbler and western yellow-billed cuckoo, use riparian habitat for cover, foraging, and breeding opportunities (RHJV 2000). Least Bell's Vireo historically occupied these areas, but has since been extirpated. Target plant species growing on floodplains in the San Joaquin River Basin floodplains include delta coyote-thistle, northern California black walnut, and elderberry, the host plant for valley elderberry longhorn beetle (VELB). Within the San Joaquin River Basin, about one third of the documented occurrences of Delta coyote-thistle have been extirpated primarily as a result of conversion of riparian vegetation to other land cover types (Jones & Stokes 2002; CNDDB 2001). Historical distribution and abundance of VELB is not well documented (USFWS 1984b, Griffin and Critchfield 1972). However, VELB depends on elderberry, a species in Central Valley riparian vegetation, and therefore declines in riparian vegetation have probably caused declines in VELB populations. Northern California black walnut is not native to the San Joaquin River Basin but currently occurs there. Two mammal species, San Joaquin woodrat and riparian brush rabbit, also use riparian vegetation in the San Joaquin River basin. The San Joaquin woodrat has declined approximately 90 percent from historical numbers (Katibah 1984), and today the species is known to occur at only one location with a peak estimated population of 435 individuals (Williams 1993). Similarly, riparian brush rabbit is currently restricted to the Lower Stanislaus River (Jones & Stokes 2002). Throughout the Central Valley, populations of birds, mammals, insects, and plant species have declined, primarily as a result of loss and degradation of habitat (Gaines 1980, RHJV 2000, USFWS 1984a, Jones & Stokes 2002).

Many native fish species including splittail and Chinook salmon are dependent on or could benefit from inundated floodplains in the lower reaches of the San Joaquin and its major tributaries. The floodplain functions as a nursery area, a refuge from low water temperatures in early spring and winter, and a refuge from high water velocity (Turner et al. 1994). It also provides high food abundance, a range of water temperature conditions, and increased water clarity that may increase growth and survival rates (Sommer et al. 2001a, 2001b). Seasonally inundated floodplains, though providing habitat for both native and non-native fish species, is particularly important to native species (Moyle et al. 2000). For example, declines in splittail abundance have been attributed to drought conditions resulting in a reduction of shallow inundated floodplain area (Sommer et al. 1997, Baxter 2000). Splittail spawn in shallow areas, including inundated floodplains, and deposit adhesive eggs over flooded banks and aquatic vegetation (Moyle 2002, Wang 1986).

Floodplain restoration reintroduces the physical and biological processes that establish and maintain wetland and riparian vegetation and provide habitat for native fish and wildlife species. For example, levee breaches and levee setbacks reconnect portions of isolated floodplains to the river channel. Temporary inundation saturates soil, transports seeds and nutrients, and deposits bare sediment that facilitates seed germination and seedling establishment. Periodic inundation of floodplains is therefore expected to increase the quantity and quality of wetland and riparian vegetation (Jones & Stokes 2002).

Floodplains along all rivers and streams may be better managed to facilitate natural deposition of sediment. For example, buffer strips or riparian zone setbacks could be established along stream courses. Other potential actions include removing artificial berms or levees (where feasible) that restrict the amount of available floodplain area and planting riparian vegetation on floodplain surfaces to slow water velocities and encourage sediment deposition. Also, fine sediment in pools, riffles, riparian berms, and backwaters may be excavated and mechanically flushed. On the Tuolumne River, an example of stream restoration actions implemented to increase floodplain habitat includes evaluation of a proposed sedimentation pond near the mouth of Gasburg Creek and a head-control structure to prevent channel incision on lower Dominici Creek.

The implementation of actions should follow a full assessment of their potential for a contribution to salmonid life stage survival and production, including effects of sediment on habitat that supports passage, spawning and incubation, and rearing. For example, in the Tuolumne River, relatively low survival from egg to emergence for Chinook salmon (average of 34 percent, range of 0 percent to 68 percent), was associated with high concentrations of fine sediment and organic detritus in redds (EA Engineering, Science and Technology 1992 in Mesick 2001). Similar studies may be warranted on other rivers to determine the increase in fry production that could be realized by reducing fine sediments.

Actions should be prioritized based on the potential to reduce fine sediment in spawning gravel and to increase egg to fry survival. The efficiency of actions to reduce sediment input and reduce fines should be assessed for primary spawning and rearing habitat. Studies should include both physical conditions (e.g., fine sediment sources, input, transport, and storage) and biological conditions (e.g., egg survival, invertebrate production, and interstitial cover). The potential for restoring fluvial geomorphic processes throughout the watershed (e.g., restoration of flow and watershed health) should be considered in addition to actions that address focused environmental conditions (e.g., flushing flows and/or mechanical removal of fines).

Coarse Sediment (Gravels). Along most Central Valley rivers and streams, sediment supply and transport have been altered by hydraulic mining, levees, land use changes, gravel mining, dam construction, and water diversions (CALFED 2000a). Currently, managed forest lands, roads, construction, and developed and agricultural lands are contributing substantially more sediment than they did under the previous cover of natural vegetation (Charbonneau and Kondolf 1993). In the lower portions of watersheds, most of this sediment is of fine materials (<2 mm in diameter). On most rivers and streams, dams block the transport of coarser materials from the upper portions of watersheds, while gravel mining has removed coarse materials from downstream river floodplains and channels. As a consequence of these changes, spawning and rearing habitat for Chinook salmon and steelhead has been reduced.

The construction of dams has contributed to accelerated channel erosion below the dams and to a change of particle size on the riverbed (Kondolf 1997). Water released from dams is relatively free of sediment. This sediment-free flow erodes the channel bed and banks, may incise the channel, and moves coarse and fine sediment downstream. Without the input of properly sized coarse sediment from upstream, the area of gravel beds in the channel is reduced, and the remaining gravel is often of larger sizes that are not mobilized by flows released from the dam (i.e., armoring of the channel). This armoring of the channel reduces the quantity and quality of salmonid spawning habitat. Dams also reduce peak flow, resulting in a reduction of channel size and accumulation of finer sediment along and within the river channel (Kondolf 1997). The resulting narrowing of the channel and accumulation of fine sediments reduce both the quantity and quality of salmonid spawning habitat.

Fine Sediment. A primary factor in the decline of all fish species is reduced spawning and rearing habitat. For salmonid spawning habitat, particle size is one of the main factors that affect embryo survival, time of emergence, and size of emergent fry (Bjornn and Reiser 1991). The input of fine sediment contributes to this reduction in habitat quality and quantity. Fine sediments fill in particle interstitial spacing, which will decrease spawning gravel quality due to reduced permeability of sediment to water flow and thus reduce the availability of DO. For their survival, salmonid eggs require high rates of water flow to maintain adequate oxygen concentrations (Healey 1991). Increased fine sediment decreases permeability of flow, decreases oxygen supply and increases mortality (Tappel and Bjornn 1983, Waters 1995, Ligon et al. 2003).

Consequently, optimal conditions for spawning of Chinook salmon and steelhead require less than 10 percent fine sediment (Raleigh et al. 1986). Fine sediment that exceeds 30–40 percent by volume significantly reduces embryo survival. A high percentage of fine sediment also can impede the movement of fry from the redd.

Researchers have found that elevated concentrations of suspended sediment also can cause direct mortality to fry, fingerlings, and juvenile salmonids (Lloyd et al. 1987, Sigler et al. 1984, Reynolds et al. 1989). Sub lethal effects include avoidance of sediment-laden areas, reduced feeding and growth, respiratory impairment, reduced tolerance to disease and toxicants, and physiological stress (Waters 1995). Excessive deposition of fine sediment may cause a change in macroinvertebrate species composition, shifting from larger invertebrates dependent on larger interstitial spaces (generally, the most important food for steelhead and Chinook salmon) to small burrowing forms that are less available to foraging fish (Waters 1995).

Excessive deposition of fine sediments does affect spawning gravels in the San Joaquin River Basin. For example, in the Tuolumne River, relatively low survival from egg to emergence for Chinook salmon (average of 34 percent, range of 0-68 percent) was associated with high concentrations of fine sediment and organic detritus in redds (EA Engineering, Science and Technology 1992 in Mesick 2001).

Several factors affect the quantity of sediment eroded from a watershed and deposited in streams and streambeds: rainfall patterns, slope length and steepness, erodibility of soils, vegetative cover, stream bank attributes and erosion control practices. Human-induced fine sediment loading is primarily due to changes in land use that alter the cover to vegetation. The four main land uses generating sediment in the San Joaquin River Basin are agriculture, in-channel mining, silviculture, and construction.

II. Habitats

Essential Fish Habitat. Portions of the San Joaquin, Stanislaus, Tuolumne, and Merced rivers have been identified as EFH, based on the definition of waters currently accessible to salmon. The vision for EFH is to maintain the quality of habitat available through actions directed towards improving streamflows, coarse sediment supply, water quality, access and passage, stream meander, natural floodplain and processes and maintaining and restoring riparian and riverine aquatic habitats. ERP Goal 4 is to protect, restore, or enhance habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics. ERP and EFH have a similar vision for habitat restoration and ERP will continue to support projects that target conservation priorities under Goal 4 (see Section 5).

Freshwater Habitat. Freshwater habitat of salmon includes all the physical, chemical, and biological elements within the aquatic environment. Geology, climate, topography, disturbance history, nutrients from returning salmon, and characteristics of the riparian vegetation typically govern the characteristics and the distribution of habitat types in a watershed. Components of freshwater habitat include:

- Physical Characteristics - channel width and depth, substrate composition, pool and riffle frequency, pool types, and channel roughness.

- Water Quality and Quantity - temperature, dissolved oxygen, dissolved nutrients, dissolved and particulate organic matter, and hydrography.
- Cover factors - interstitial spaces (space between gravels), undercut banks, woody debris, and water surface disturbance.
- Biological Factors - food availability, salmon carcass nutrient inputs, competition, predation, disease, parasites, and functioning riparian conditions.
- Climate and regional geology determine habitat conditions at large spatial scales. The type of bedrock, the glacial history, and precipitation patterns contribute to landscape and channel morphology.

Floodplain Reconnection and Functional Riparian Corridors. Streams and their adjacent riparian zones are ecosystems closely linked by flows of organic and inorganic materials and the movements of organisms. Ecologists have long recognized that these systems are strongly influenced by the exchange of materials such as nutrients, leaves, and woody debris (Likens & Bormann, 1974; Hynes, 1975). However, recent research has focused attention on two direct “prey subsidies” (Polis et al. 1997), terrestrial invertebrates that fall into streams and feed fish, and the reciprocal flow of adult aquatic insects that emerge and feed riparian consumers like birds and spiders. Within both habitats, these subsidies have effects at individual, population, community, and ecosystem levels.

Inundating the floodplain is key to providing organic nutrients to the river ecosystem. Inundated floodplains provide cover, food and warmer temperatures in late winter through early spring for rearing and migrating juveniles. Connecting floodplain inundation to flow values is a complicated task requiring intimate knowledge of each tributary river system. What has not been determined is what flows generate inundated floodplain conditions.

In supporting the SWRCB’s efforts to establish flow requirements as a percent of unimpaired flow, CDFW stresses that any flow percentages chosen must generate sufficient flows during the critical late winter and early spring periods to inundate each tributary’s floodplains.

Riparian Corridor. Riparian vegetation throughout the Sacramento River and San Joaquin River valleys has been significantly reduced from historical levels by land use practices, beginning with the introduction of cattle in the 1770s, sedimentation caused by hydraulic mining in the 19th century, and continuing with land conversion in the 20th century (CALFED 2000b, The Bay Institute 1998). Estimates place the loss of woody riparian vegetation in the Central Valley at 92–97 percent, with the remaining riparian forests frequently of relatively poor quality (Hunter et al. 1999, CALFED 2000b, Jones & Stokes 2002). Riparian habitat has been significantly reduced by stream channelization, riprapping of stream banks, altered hydraulics, livestock grazing, and direct loss of habitat to agriculture and urban development (RHJV 2000, CALFED 2000b). As a result, wildlife corridors are narrow, riparian habitats fragmented, stream temperatures increased, channel variability decreased, and little or no regeneration of riparian vegetation is occurring at many sites (CALFED 2000b).

Riparian corridors are key landscape components in maintaining biological connections along extended and dynamic environmental gradients (Naiman et al. 2005). Perhaps the best evidence for plants using riparian zones as corridors comes from exotic invasions such as the expansion of giant reed throughout the San Joaquin River Basin and the incipient expansion of scarlet wisteria. However, it is not clear that riparian zones function as dispersal corridors in all cases. Certainly, adaptations of many plants allow vegetative fragments and seeds to float for various distances, while many other riparian species are dispersed by wind or animals.

Riparian corridors also act as physical buffers for sediments and sediment-bound pollutants carried in surface runoff. These can be filtered and deposited effectively in mature riparian forests as well as in streamside grasses. Sediment deposition may be substantial in the long term especially along the western side of the San Joaquin River where erosive soils from the Coastal Mountains may contribute significant loads to flood waters. The finer sediments carry higher concentrations of nutrients and adsorbed pollutants from agricultural lands and other areas. Their removal from the runoff can be a significant benefit for the water quality of the system downstream. In areas with significant riparian forests and functioning floodplains, riparian zones can be sources or sinks for nutrients, depending on oxidation-reduction conditions and the type and extent of flood flows.

Existing vegetation also can play a role in seedling germination and establishment. Cottonwood and willow seedlings are most likely to establish on bare ground. However, other species, such as Oregon ash and valley oak, establish concurrently or subsequent to the willows and cottonwood, and grow more slowly but are more tolerant of shade (Burns and Honkala 1990, Tu 2000).

Much research on regeneration of riparian species has been conducted on various rivers in the arid western US. Most of this research was conducted outside California (e.g., Stromberg et al. 1991; Scott et al. 1997), although several symposia have highlighted the importance of research on riparian systems in the Central Valley (Sands 1977; Warner and Hendrix 1984). Specific research on the riparian systems on the Central Valley is necessary to help guide management decisions that would contribute to the restoration of riparian regeneration along the Sacramento and San Joaquin rivers. Site-specific field studies in combination with greenhouse studies and modeling as conducted by Stella et al. (2003a, b) in the San Joaquin Valley may help guide such management decisions.

A program for determining appropriate conditions for seedling germination and establishment should include consideration of hydraulics in site selection. Sites where low floodplains situated along the stream channel are subject to infrequent inundation every 5 to 10 years may be well suited to seedling establishment. However, establishment of riparian vegetation would increase roughness and thus reduce flood conveyance. Hydraulic models can be developed and applied to assess whether large flows will be safely conveyed after roughness has increased as a result of riparian restoration at specific sites. The use of levee breaches to provide sediment and inundation for riparian restoration (Trowbridge et. al. 2000) also would require detailed consideration of hydraulics.

The loss of riparian vegetation has been an important factor in the decline of the California yellow warbler, western yellow-billed cuckoo, Least Bell's Vireo, and little willow flycatcher. Within California's Central Valley, all of these species depend on riparian vegetation for cover, foraging, and breeding (RHJV 2000). Within riparian vegetation, dense, low, shrubby vegetation is a particularly important habitat component for these species (Dunn and Garrett 1997, Brown 1993, RHJV 2000). In addition, landscape attributes such as patch size and surrounding land uses affect these bird populations. For example, populations of western yellow-billed cuckoo persist best in large blocks of riparian forest (20–80 ha and often more than 300 ft in width) of meandering riparian zones (Halterman 1991). Significantly, surrounding land uses and patch attributes affect parasitism by brown-headed cowbird, which is a major stressor affecting these species (Harris 1991, Beezley and Rieger 1987, Laymon 1987).

A program for restoring riparian habitat also should include sufficient monitoring to guide adaptive management of this and related restoration efforts. Monitored variables should allow evaluation of resulting habitat quality and quantity for target species and habitat use by target species. Performing all aspects of such monitoring may be problematic for a small program, and regional syntheses of disparate monitoring efforts may have limited value for the ERP. Thus, monitoring, particularly assessment of habitat use, may be most effective if designed, coordinated, and/or performed in the context of the ERP.

Shaded Riverine Aquatic Habitat. The loss of shaded riverine aquatic habitat (SRA) cover is a potential factor in the decline of all fish species. Riparian vegetation filters sediments, inputs woody debris and organic matter, modifies channel pattern and geometry, creates SRA cover, and provides habitat for aquatic invertebrates eaten by salmonids. For these reasons, stream sections shaded by riparian vegetation provide optimal conditions for rearing and resting areas for adult Chinook salmon and steelhead migrating upstream (CALFED 2000b; Haberstock 1999; Slaney and Zaldokas 1997; Raleigh et al. 1984, 1986). Woody material is important because it provides the hydraulic diversity necessary for selection of suitable velocities, access to drifting food, and escape cover from predatory fish (Peters 1998). Additionally, the input of large woody material into the river system increases the complexity of habitat and fosters the creation of pools for holding juvenile salmon during high flow events (Larson 1999, Macklin and Plumb 1999). Shade reduces daily temperature variability and maximum temperature, maintains DO, and may help maintain base flows during dry seasons (CALFED 2000b, Haberstock 1999, Slaney and Zaldokas 1997, Whitting 1998). SRA cover is important to juvenile Chinook salmon and steelhead because it provides high-value resting and feeding areas and protection from predators. This could prove especially beneficial in the East San Joaquin drainages, where large gravel mining operations have created habitats favorable for salmonid predators such as non-native centrarchids (CALFED 2000b).

A cooperative program to plant vegetation on unvegetated riprapped banks could increase SRA cover and provide additional habitat for aquatic and terrestrial species (Shaffter et al. 1983, Peters et al. 1998, Michny and Deibel 1986). This vegetation also may contribute to the stability of the riprapped bank (Shields 1991). However, additional vegetation would increase hydraulic roughness and reduce conveyance of floodwaters. Therefore, hydraulic models would need to be applied to assess whether large flows will be safely conveyed after roughness has increased as a result of plantings of riparian vegetation. Recommendations for revegetation will only occur in areas where the geomorphology will support restoration and provide public safety from flood events.

III. Stressors

ERP identified several stressors that negatively affect the San Joaquin Valley's ecosystem health as measured by native species, ecological processes, and habitats. The focus in this element of the Conservation Strategy for the San Joaquin Valley is on stressors including NIS, water and sediment quality, water diversions, and barriers to connectivity of habitats (such as levees, dams and other structures).

Loss of Habitat. Floodplain habitat has been dramatically altered along the San Joaquin. Many miles of meandering natural backwater sloughs have been eliminated, replaced by straightened, lightly-vegetated drainage ditches whose flow levels are carefully controlled and discharged back to the river. Most of the natural flood basins are now only connected with the river system during floods. As a result, the once extensive riparian zones and wetlands that historically bordered lowland rivers and occupied much of the flood basins have been almost entirely lost, mostly converted to agricultural production.

Changes in Flows**.** The hydrology of the San Joaquin River Basin system has been significantly altered by dams and diversions, which supply water to support a multi-billion dollar agricultural industry in the San Joaquin Valley (Cain 2003). On the Tuolumne River, median monthly flows in all months have been reduced by about two-thirds, and a once dynamic annual hydrograph has been converted to a nearly uniform discharge pattern. Monthly flow variability has also been reduced to about one-fifth of its prior value. Similar changes are evident on the San Joaquin River below Friant Dam.

Non-Native Invasive Species

Non-native Invasive Species (NIS). Non-native species of fish, macroinvertebrates, and terrestrial and aquatic plants are abundant and widespread within the San Joaquin River Basin. The ecological impacts of many of these invasive species have not been studied. There is still much to be learned about the extent of their impacts. NIS have the potential to disrupt and alter ecosystems as their populations expand. Plant invasions frequently begin with a prolonged period of limited distribution and abundance before the species spreads more rapidly (Kowarik 1995, Mack et al. 2000). Once a species is widespread and abundant, mechanical and/or chemical removal can be prohibitively expensive, and after an invasive species is removed it frequently re-invades (Groves 1989, Luken et al. 1997, Drayton and Primack 1999).

Water and Sediment Quality

Dissolved Oxygen (DO). Low DO concentrations can both reduce the suitability of areas for spawning or rearing and block or delay passage to suitable habitat for spawning and rearing. In the lower San Joaquin River drainage, low DO, high water temperature, and a lack of attraction flows appear to cause blockage or delays and straying during upstream migration of fall-run Chinook salmon (San Joaquin River Management Program 1992). These three environmental factors are correlated; however, the contribution of each factor to blockage, delays, and straying during migration is not well understood (Alabaster and Hallock 1988 and 1970 in McCullough 1999).

Delayed or blocked passage can have several detrimental consequences. First, adult fish may be blocked from their upstream spawning habitat. Second, it may increase exposure of adult Chinook salmon and steelhead to water temperature detrimental to individual survival and to the fecundity of females. Third, delayed passage of adults may also delay spawning and extend incubation of eggs and rearing of juveniles into months with warmer water temperatures. This may reduce egg and juvenile survival and reduce year-class production. Fourth, delayed or blocked passage of juveniles may prevent access to downstream rearing habitat and increase exposure to warm water temperature, entrainment in diversions, and predation. The resulting decrease in survival and growth rates reduces year-class production and potentially reduces adult abundance.

The DWSC portion of the San Joaquin River has experienced periods of low DO leading to its listing under Section 303(d) of the Clean Water Act and subsequent TMDL. The periods of most prolonged and acute exposure occur during June through October. The Basin Plan for the Sacramento and San Joaquin River Basins contains a water quality objective requiring that oxygen levels be maintained above 6 mg/l between September 1 and November 30 and above 5 mg/l at all other times. The 6 mg/l objective was adopted to protect the upstream migration of fall-run Chinook salmon by the SWRCB in 1991.

Early studies identified three main factors contributing to this DO impairment: 1) Loads of oxygen demanding substances from upstream sources that react by numerous chemical, biological, and physical mechanisms to remove DO from the water column in the DWSC; 2) DWSC geometry impacts various mechanisms that add or remove DO from the water column, such that net oxygen demand exerted in the DWSC is increased; 3) Reduced flow through the DWSC impacts mechanisms that add or remove DO in the water column, such that net oxygen demand in the DWSC is increased. The Central Valley Regional Water Quality Control Board has developed a TMDL to remedy this water quality issue (CVRWQCB 2005).

Several actions have taken place in response to the TMDL. The City of Stockton added two nitrifying towers and wetlands to reduce ammonia discharges. DWR has overseen construction and testing of performance and effectiveness of an aeration device at Rough and Ready Island that when operating would at times be able to increase DO concentrations to levels to achieve compliance with the standards (ICF International 2010). The ERP provided funding for studies to further characterize and evaluate suspended algae (e.g., phytoplankton) entering the San Joaquin River from upsteam sources that could be contributing to the DO sag in the estuary. These "upstream studies" included measurements of flows and nutrient and algae concentrations in 2005–2007. Additional modeling of the watershed and river water quality was initiated using a TMDL model called Watershed Analysis Risk Management Framework (WARMF). Studies of the "transition zone" between the river conditions at Vernalis and Mossdale and the water quality entering the DWSC were included. The ERP separately funded two DWSC multi-dimensional modeling efforts, based on recommendations from the 2002 peer review by the independent science panel convened by CALFED. A current study is underway to collect and analyze data on the sources of nutrients, phytoplankton, and oxygen-consuming materials in the San Joaquin River estuary (an area not evaluated in the "upstream studies" efforts) to expand the model that was developed. Upon completion, this model can be used as a management tool to resolve low DO concentrations in this watershed.

Continued actions to minimize or eliminate DO sags in the lower San Joaquin River near Stockton could include:

- Completing studies to identify causes for DO sags in the San Joaquin River near Stockton.
- Defining and implementing corrective measures for DO sags.
- Finalizing the investigation of methods to reduce constituents that cause low DO for inclusion in TMDL recommendations by the Central Valley RWQCB.
- Development of a Basin Plan Amendment and TMDL for constituents that cause low DO in the San Joaquin River.
- Implementing appropriate source and other controls and other management practices, as recommended in the DO TMDL, to reduce anthropogenic oxygen depleting substances loadings and minimize or eliminate low DO conditions.

Contaminants. The presence of contaminants in the San Joaquin River can adversely affect attempts to restore fish, wildlife, and plant communities. Selenium and pesticides are of particular concern in this system.

Selenium. Selenium is a trace element present in the marine sedimentary rocks that make up the Coast Ranges that border the San Joaquin Valley to the west. Overtime, this material has weathered and been transported to the valley floor contributing selenium to the soil, surface water, and groundwater. Irrigation water applied to agricultural lands in the Grasslands area of the west side of the San Joaquin Valley leaches the selenium from the soil into the shallow groundwater. Tile drainage systems have been installed in most fields to leach the shallow groundwater out of the root zone to protect crops. Along with this shallow groundwater, selenium is transported via the tile drain network into canals and the lower river where it is transported to the Delta.

Selenium loading of the Bay-Delta ecosystem is driven mainly by loads entering the Delta from the San Joaquin River. Portions of the San Joaquin River immediately downstream of the Grasslands, Salt Slough, and Mud Slough contain selenium at concentrations that frequently exceed levels considered safe for fish and wildlife species. The Central Valley Regional Water Quality Control Board has adopted the US EPA aquatic life criterion for total selenium of 5 µg/L four-day average as the selenium water quality objective for the lower San Joaquin River. In addition, a biological opinion and formal consultation by the USFWS and NMFS (1998 and amended 2000) on the US EPA criterion for selenium (5 µg/l) determined that such criterion jeopardizes the long-term viability of delta smelt, splittail,, steelhead trout, Chinook salmon, California clapper rail, California least tern, giant garter snake and California red-legged frog. The USFWS proposed a 2 µg/l chronic criterion for protection of aquatic life for all waters within the range of listed endangered species in California (USFWS and NMFS 1998 and amended 2000).

Selenium can be highly toxic to aquatic life at relatively low concentrations, but it is also an essential trace nutrient for many aquatic terrestrial species. The range between toxicity and nutritional deficiency is narrow. Bioaccumulation of selenium by lower trophic level invertebrates (such as zooplankton and bivalves) is a critical step in determining effects of selenium. Invertebrates are the source of selenium exposure to higher trophic level predators such as fish and birds. Estuarine invertebrates are exposed to selenium through: direct uptake of dissolved selenium; primary producers taking up selenium and then being consumed by animals; and/or direct uptake of detrital or sedimentary selenium enriched particles via filter-feeding or deposit feeding. In the Bay-Delta, bivalves appear to be the most sensitive indicator of selenium contamination (Pressor and Luoma 2006).

In 1983, the death and deformities of waterfowl at Kesterson Wildlife Refuge first focused attention on agricultural drainage and selenium. Stewart et. al. (2004) reported that recent field studies in the estuary have found Sacramento splittail with deformities typical of selenium toxicity. Additionally, Stewart et. al. (2004) concluded that sturgeon are on the cusp of reproductive impairment from exposure to selenium.

Salmonids are relatively sensitive to selenium compared to other fish species (DRERIP 2009). Beckon (2007) evaluated selenium data from the San Joaquin River and concluded that, although discharges of selenium to the San Joaquin River have been reduced over the last 15 years, selenium will pose a substantial risk to salmon that are reintroduced to restored middle reaches of the river unless selenium loads are further reduced and/or sufficient dilution flows are provided (DRERIP 2009).

The seasonal use of the habitat may reduce the potential magnitude of selenium impacts to covered fish species, especially juvenile salmonids. Seasonal use of the Delta by juvenile salmonids occurs mainly during high flow periods (January-June), whereas, highest concentrations of selenium occur during low flow periods. However, this seasonal difference does not provide strong protection because selenium bioaccumulates in food chains, is recycled in the ecosystem, and can have significant lag times between when loading occurs and when effects are seen. The invertebrate prey of juvenile salmonids is water-column-feeding or detritus-feeding species that are relatively less contaminated than certain suspension or deposit-feeding bivalves. Adult splittail and sturgeon feed on bivalves and would be expected to have greater exposure to selenium in their diet than salmonids.

Habitat modification that creates more extensive floodplain and low velocity, shallow water habitats create a better environment for selenium partitioning in food chains than would occur in bed sediment of the river channel. Exposure of covered fish to selenium might increase due to higher bioaccumulation of selenium in invertebrate prey and longer residence time of the fish in the restored habitat. The effect would be minimal due to the infrequency of inundation (inundated >30 days once every 7 to 20 years). Selenium dynamics in the Bay-Delta system are fairly well understood, but there is uncertainty about how changes in management of San Joaquin River flows, water exports, and potential future actions to solve the drainage problem on the west side of the San Joaquin Valley could affect selenium loading and cycling in the Delta (DRERIP 2009).

A tool, the Bay-Delta selenium model (Presser and Luoma 2006), has been developed to generate site-specific forecasts of selenium concentrations and effects based on loads, prey, and predators. Building off of earlier USGS work conducted with ERP funding, the model reports on two lines of evidence to show the general magnitude of the accumulated selenium reservoir in the western San Joaquin Valley. Calculations at the lower range of projections show that a long-term reduction in selenium discharge would not be expected for 63 to 304 years, if selenium is disposed of at a rate of about 42,500 lbs. per year.

Solutions to the selenium issue in the San Joaquin River Basin are closely tied to overall water management in the region. Implications for water management found through use of a range of selenium load scenarios and the comprehensive approach illustrated in the Bay-Delta selenium model are:

- The most significant effects of irrigation drainage disposal into the Bay-Delta will occur during low flow seasons and especially during low river flow conditions in dry or critically dry years. Dry or critically dry years have occurred in 31 of the past 92 years; as noted earlier, critical dry years comprised 15 of those years. Any analysis of selenium effects must take the influences of variable river inflows into account.
- Selenium effects in the Bay-Delta also could increase if water diversions increase or if San Joaquin River inflows increase with concomitant real-time discharge of selenium that increases selenium loading (the selenium issue and the water management issues are tightly linked).
- Construction of an extension of the San Luis Drain would increase selenium exposures of Bay-Delta organisms under any scenario partly because the entire

load is unequivocally conveyed directly to the Bay-Delta. The greatest risks occur if discharge is continuous through high and low flow periods. Discharges from a San Luis Drain extension are especially problematic if they are constant through low inflow periods, when the dilution capacity of the estuary subsides dramatically because of diversions of freshwater inflows. Freshwater diversions, the resultant volume of inflow, and the degree of treatment of the waste are critical in determining the extent of the effect of a San Luis Drain extension.

- Treatment also may be important in determining source loads effects. Treatment technologies applied to source waters may affect both the concentration and speciation of the effluent. For example, a treatment process could decrease the concentration of selenium in the influent, but result in enhanced selenium food chain concentrations if speciation in the effluent changes to increase the efficiency of uptake (Presser and Luoma 2006).

Pesticides. Chlordane, DDT, and toxaphene are persistent, synthetic, organochlorine insecticides formerly widely used in the San Joaquin Valley and Sacramento Basin (Brown 1997, Domagalski et al. 1998a, b; Kuivila and Foe 1995). These compounds are acutely and chronically toxic to fish and wildlife (DeLong et al. 1973, Colborn and Clement 1992, Clark 2001). They are very persistent in the environment and are known to bioaccumulate and bioconcentrate within food webs. Chlorinated hydrocarbons such as DDT are highly insoluble in water, with an aqueous saturation concentration of less than 1 ppb, but they are soluble in fats and may adsorb to particles. The distribution and bioavailability of these compounds in estuarine systems is largely associated with the presence of suspended sediments and microorganisms such as diatoms. Thus, filter-feeding organisms that directly or indirectly ingest sediment particles and microorganisms, and organisms that prey on these first-order consumers therefore form a primary route for accumulation and transfer of chlorinated hydrocarbons in both marine and terrestrial food chains. Because these compounds are difficult to excrete and are lipid-soluble, they tend to accumulate and concentrate in the fatty tissues of receptor organisms, leading to bioaccumulation and biomagnification through the food web.

DDT concentrations have declined in the San Joaquin River Basin and the Delta since the late 1970s and early 1980s (Davis et al. 2000). Data from Davis et al. (2000) suggest that PCB concentrations are elevated in largemouth bass and white catfish in localized hotspots rather than regionally. Smith Canal by Yosemite Lake and the Port of Stockton had the highest concentrations. These studies did not include any listed species such as Chinook salmon or delta smelt. Specific information on the target species is lacking.

Implementation of sediment reduction activities would reduce the amount of organochlorine residues transported and rendered bioavailable in the San Joaquin and Sacramento rivers systems. Use of sediment reduction BMPs on agricultural lands and other specific sites where many of the elevated concentrations have been identified would also be a highly constructive step to reduce concentrations of bioavailable organochlorine residues. Use of BMPs for urban/industrial stormwater runoff and discharges would reduce both PCBs and organochlorine insecticide loading in the Delta and Eastside tributaries. Determining the ecological significance of pesticide discharges, with particular emphasis on bioaccumulation and biomagnification potential, would allow increasingly effective ecological management. Finally, monitoring to determine the effectiveness of sediment and runoff BMPs would be essential to minimizing injury to aquatic or terrestrial wildlife from exposure to these pesticides.

Diazinon is highly toxic to birds (Hill and Camardese 1984, Stone 1985), terrestrial insects (Mackenzie and Winston 1989), aquatic invertebrates (Hatakayama and Sugaya 1989, Robertson and Mazzella 1989), and soil microbes (Ingham and Coleman 1984). It is also toxic to fish, but does not exhibit the extreme toxicity that warrant concerns for direct, lethal effects on fish (Turner 2002). However, it is highly toxic to the aquatic invertebrates that serve as food for fish and can therefore affect fish populations indirectly. Also, diazinon can have significant sub lethal effects on olfaction in fish, including the Chinook salmon, thereby impairing homing ability, mate finding and predator avoidance behaviors (Scholz et al. 2000). Based on laboratory toxicity testing, a California-specific acute ambient water quality criterion for diazinon is 0.08 µg/l and a chronic value of 0.04 µg/l (Menconi and Cox 1994). Diazinon levels measured in the Merced, Tuolumne, and San Joaquin rivers during winter storm runoff frequently exceed 0.35 µg/l (Kuivila and Foe 1995, Domagalski et al. 1998a, Kratzer 1997).

Development of hazard assessment criteria and TMDLs for each pesticide will provide standards for measurement of effect thresholds and prioritization of management actions directed toward impact reduction. Development, implementation and monitoring of BMPs for pesticide use will ensure minimization of misuse and consequential environmental impacts throughout the Delta and associated watersheds. Finally, research on the ecological significance of pesticide discharges will allow controlled evaluation of how event-related pulses of pesticide exposure affect resident species and provide insight into how best to moderate or eliminate these impacts.

Water Diversion and Barriers

Water Diversions and Fish Barriers. Water diversions affect fish, aquatic organisms, sediments, salinity, streamflow, habitat, food web productivity, and species abundance and distribution (NMFS 1994). Some diversions have screens that exclude larger organisms, but eggs, larvae, invertebrates, plankton, organic debris, and dissolved nutrients, which are important components of the lower trophic levels, are lost to diversions. Reductions at the lower trophic levels can result in impacts on all higher trophic levels affecting the overall food web.

Direct effects of diversions on fish include migration delay, injury, and mortality caused by entrainment, impingement, and predation (NMFS 1994). Entrainment occurs when fish move with the diverted flow into a canal or turbine. In most cases, entrained organisms do not survive. Impingement occurs when individual fish come in contact with a screen, a trash rack, or debris at the intake. Contact causes bruising, loss of scales, and other injuries. Impingement, if prolonged, repeated, or occurring at high velocities, causes mortality. In addition, intakes increase predation by stressing or disorienting prey fish and by providing habitat for fish and bird predators (NMFS 1994).

Approximately 150 diversions exist on the San Joaquin, Merced, Tuolumne, and Stanislaus rivers (USFWS 1995b). El Solyo, West Stanislaus, and Patterson Irrigation District diversions are some of the large water diversions found between the confluence of the Merced River and Vernalis on the mainstem San Joaquin River. Patterson Irrigation District completed the screening of their 195 cfs diversion in September 2011, while Western Stanislaus Irrigation District has completed its initial alternative analysis and feasibility studies to screen its 252 cfs diversion.

In addition, six medium pump diversions exist on the Merced River and numerous small pump diversions exist on the Merced, Tuolumne, and Stanislaus rivers. Screening diversions should reduce the loss of native fishes to a level that would increase the production of vulnerable life stages and contribute to increased abundance of the affected species. The level of entrainment at diversions in the San Joaquin River and its tributaries is not well documented (USFWS 1995b). The species life stage response relative to substantial effects on productivity and survival are even more uncertain, especially when factors other than losses to diversions (e.g., habitat area and response to flow conditions) are limiting.

The remaining diversions on the system should be prioritized for improved screens. Species vulnerability to entrainment should be considered in relation to the timing, duration, and location (in the San Joaquin Basin and within the water column) of diversions. Simulation of the population effects will be pivotal in prioritizing the diversions selected for consolidation and screening. The population effect should encompass variability in life stage abundance that may occur in response to meteorology and other environmental conditions. Entrainment rates should be based on life stage vulnerability relative to behavior, distribution, timing and measured entrainment, and life stage densities at representative diversions (Afentoulis 2002, Cook and Buffaloe 1998). Further experimental studies are needed to determine the effectiveness of different mechanical and operational solutions (CALFED 2001a, 2000a; USFWS 1995b).

IV. Species

ERP Goal 1 (Endangered and Other At-risk Species and Native Biotic Communities) is to initiate recovery of at-risk native species as the first step toward establishing large, self-sustaining populations of these species and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed. ERP intends to continue working toward species recovery by focusing on restoring environmental processes, creating suitable habitat areas, and reducing stressors, rather than taking a narrow species-by-species approach to conservation. As stated in the Sacramento-San Joaquin Delta Section, the following discussion is on a small subset of the species targeted by ERP.

Chinook Salmon. Chinook salmon (*Oncorhynchus tshawytscha*) populations have continued to decline in the San Joaquin Valley, in large part due to the habitat degradation and water diversions resulting from the establishment and operation of the various dams. Natural riverine processes, necessary to keep a river channel in a healthy condition, have been altered and are further threatened by encroaching land development and the removal of native riparian vegetation. Coupled with insufficient flow regimes following dam construction, this has resulted in static river channels that are either choked with or devoid of vegetation, do not allow channel scouring necessary to maintain proper river form and function, create contitions that support predator species, enhance predation opportunity, and create water temperature regimes that are not conducive to salmonid species.

Similar to salmon population trends in other watersheds, the San Joaquin River fall-run Chinook salmon population has been highly erratic in historical escapement estimates (Figure 6). The spawning adult salmon populations ranged from between 80,000 (1953) to 320 (1963). Data suggest that the east-side tributary fall-run boom and near-bust cycles have existed for at least the last 80+ years. However, reductions in peak abundance over time is troubling and suggest that overall population resiliency is decreasing and may reach a point where prolonged drought condition could lead to extinction. Salmon population trends in the east-side tributaries show a steady decline from 1952 to 1979, when the last large dam (New Melones) was built. As evidenced by the average escapement for the years 1952 to 1979 of 20,360 returning adult fish per year, compared to the 1980 to 2008 returns averaging 16,200 fish per year.

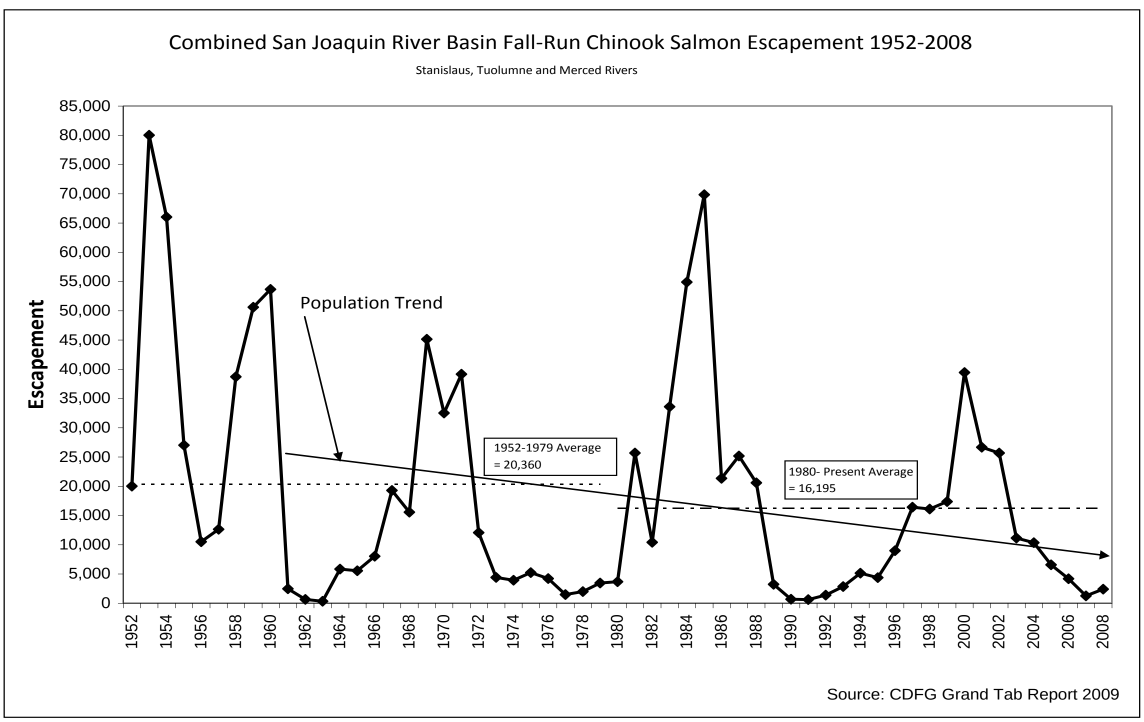

Figure 6: Combined San Joaquin River Basin Fall-Run Chinook Salmon Escapement from years 1952 to 2008.

The Stanislaus River historically supported abundant populations of spring and fall-run Chinook salmon and steelhead. In response to Gold Rush era expansion in the area, the Stanislaus River had begun to be dammed and diverted for agriculture and gold mining purposes. In 1886 the California Fish and Game Commission stated that the Stanislaus River had once been a preeminent salmon stream, but by that time only an occasional salmon was seen trying to get over its multiple dams. Dam construction continued on the Stanislaus River throughout most of the 20th century. The dams include: Goodwin Dam (1918), “Old” Melones (1926), Tulloch Dam (1958) and New Melones (1979). Today, 66 miles of the river now occurs upstream of these dams and is inaccessible to salmonids (Yoshiyama et al. 1996).

The damming of the Stanislaus River resulted in a shift in dominance of the river’s various salmon runs. While spring-run salmon were historically the predominant run in the Stanislaus River, the loss of all but the lower 25 miles of spawning and holding habitat, and subsequent water flow reductions created conditions that were more suitable to support a fall-run of salmon. Fall-run Chinook population levels in the Stanislaus have fluctuated over time, but mirrored the overall declining trends of the San Joaquin Basin. Steelhead or spring-run Chinook salmon runs in the Stanislaus River, occur at levels too low to adequately estimate. A similar shift in anadromous species dominance from spring-run to fall-run has occurred in all San Joaquin tributaries.

The Tuolumne River historically supported abundant populations of spring and fall-run Chinook salmon and steelhead. In 1886, the California Fish and Game Commission noted that the Tuolumne River “at one time was one of the best salmon streams in the State…” (Yoshiyama et al. 1996). By the early 1850’s, gold mining activities along with dams and water diversions started having an impact on Tuolumne River salmon. In 1894, construction of the La Grange dam cut off nearly half of the upstream spawning and summer holding habitats. By 1896, the California Fish and Game Commission deemed the Tuolumne River runs to be at levels so low that not enough salmon remained to warrant the installation of a fish ladder at La Grange dam. Presently, only fall-run Chinook salmon occur in the Tuolumne River system.

The Merced River historically supported abundant populations of spring and fall-run Chinook salmon and steelhead. Similar to other east-side tributaries of the San Joaquin River, the Merced River began being diverted and dammed for agriculture purposes shortly after 1850. By 1928, a series of three dams had been constructed that blocked 56 miles of upstream habitat (Yoshiyama et al. 1996) and diverted most of the river for irrigation purposes. By the 1970’s, the Merced River was deemed a marginal salmon stream and the only remaining fall-run salmon were considered to be in “poor” condition. The previous decade averaged only 240 returning adults per year (DFG 2009a). In an effort to mitigate these declines, a fall-run salmon hatchery was established in 1970 below Crocker-Huffman diversion dam, and a related increase in flows necessary to support fall-run salmon was agreed to as part of the 1967 Davis-Grunsky Agreement.

Currently, however, Merced River spring-run Chinook salmon appear to be extirpated or only appear as strays from other river systems.

Conservation actions will coordinate protection, enhancement, and restoration of occupied and historic Central Valley salmon habitats with other federal, state, and regional programs. These efforts will implement measures in the restoration plan for the AFRP, the Central Valley Salmon and Steelhead Recovery Plan and applicable CDFW management measures; appropriately operate hatcheries such that natural populations are not threatened; manage fish passage to reduce predation on juveniles and increase their survival; improve export flows to improve conditions for upstream migration of adults; operate physical barriers consistent with achieving recovery goals; and determine causes and implementation of actions to address low outmigration survival of fish from the San Joaquin River in the south Delta.

Steelhead. Steelhead (*O. mykiss*) depend on essentially all habitats of the San Joaquin River system: the main channel for migrating between the ocean and upstream spawning and rearing areas and the tributaries for spawning and rearing. The construction of low elevation dams on major tributaries of the San Joaquin River has denied steelhead access to most of their historical spawning and rearing habitats in upstream areas. Although steelhead populations are much smaller than available historical records show, incidental captures of juvenile steelhead via monitoring on the Calaveras, Cosumnes, Stanislaus, Tuolumne, and Merced rivers confirm that steelhead are distributed throughout accessible streams and rivers in the San Joaquin River Basin (NMFS 2009b).

Conservation actions will coordinate protection, enhancement, and restoration of occupied and historic Central Valley steelhead habitats with other federal, state, and regional programs; implement measures in the restoration plan for the AFRP, the Central Valley Salmon and Steelhead Recovery Plan and applicable CDFW management measures; and minimize flow fluctuations to reduce or avoid stranding of juveniles.

Green and White Sturgeon. Sturgeons are native anadromous fish that inhabit both salt water and freshwater and tolerate a wide range of salinity concentrations. Spawning occurs in larger rivers upstream of the Delta. White sturgeon rear in the Sacramento-San Joaquin estuary and spawn in the Sacramento and San Joaquin rivers and their major tributaries. It is uncertain whether green sturgeon (*Acipenser medirost*) are likely to benefit from restoration efforts in the San Joaquin Valley because little is known about existing populations.

Conservation efforts will focus on major limiting factors to sturgeon populations, such as inadequate streamflows to attract adults to spawning areas, illegal harvest, and entrainment into water diversions. In addition, food availability, toxic substances, and competition and predation are other factors that influence sturgeon abundance that will be evaluated.

Splittail. Splittail (*Pogonichthys macrolepidotus*) is a native resident fish of the lower reaches of the Sacramento and San Joaquin rivers. Floodplain inundation is a significant element required to maintain strong year classes (Sommer et al. 1997). Restrictions to the floodplain, loss of marshes, and reduced winter spring river flows from flood control and water supply development have reduced the species range and abundance. Additionally, high temperature and high dissolved solids in the lower San Joaquin River reduce the use of this water resource by this species.

Conservation for splittail will continue to coordinate protection, enhancement, and restoration of occupied and historic splittail habitats with other, federal, state, and regional programs. These actions will remove diversion dams that block access to lower floodplain river spawning areas, design seasonal wetlands hydrologically connected to channels, change the timing and volume of freshwater flows, improve Delta water facility operations and water quality, screen unscreened Delta diversions, manage harvest activities, set back levees to increase shallow water habitat, and reduce the extent of reversed flows in the lower San Joaquin River and Delta during February through June.

Lamprey. In California, most records for the river lamprey (*Lampetra ayresi*) are for the lower Sacramento and San Joaquin River system tributaries in the Central Valley, especially in the Stanislaus and Tuolumne rivers (Moyle 2002). The western brook lamprey (*Lampetra richardsoni*) is a relatively small nonpredaceous fish that resides in the Sacramento and San Joaquin rivers and their tributaries. Spawning is believed to occur from July through September in the upper reaches of the San Joaquin River.

Conservation actions will align with the existing Pacific Lamprey Conservation Initiative (PLCI), a USFWS strategy to improve the status of Pacific lampreys by proactively engaging in a concerted conservation effort. The resulting collaborative conservation effort, including the State of California, will facilitate opportunities to address threats, restore habitat, increase our knowledge of Pacific lamprey, and improve their distribution and abundance. The PLCI seeks to improve the status of Pacific lamprey by coordinating conservation efforts among states, tribes, federal agencies, and other involved parties.

Sacramento Perch. Sacramento perch (*Archoplites interruptus*) populations have declined throughout their native range that included the San Joaquin River Region. Possible reasons for the Sacramento perch's decline include loss of habitat, competition with non-native species, and egg predation (USFWS 1995a).

Other At-Risk Species. While many of the ERP activities in the San Joaquin Valley Region focus on fish and aquatic resources, the ERP also provides funding to numerous studies, land acquisitions, and habitat creation efforts designed to benefit terrestrial species and plant communities. These others species were specifically identified in the ERPP and MSCS documents and their associated descriptions, actions, targets and desired outcomes in those documents are incorporated by reference in this document. The following provides a focused list of other at risk species but should in no way be construed to limit ERP's conservation focus to a level different than that identified in those earlier documents.

The following provides a focused list of other at risk species but should in no way be construed to limit ERP's conservation focus to a level different than that identified in the earlier ERPP and MSCS documents.

San Joaquin Kit Fox. The San Joaquin Kit Fox *(Vulpes macrotis mutica)* inhabited most of the San Joaquin Valley from southern Kern County north to Tracy. The largest remaining populations of kit foxes are in western Kern County on and around the Elk Hills and Buena Vista Valley in Kern County, and in the Carrizo Plain Natural Area in San Luis Obispo County.

Numerous causes of kit fox mortality have been identified, though these have probably varied considerably in relative importance over time. Researchers since the early 1970s have implicated predation, starvation, flooding, disease, and drought as natural mortality factors. Shooting, trapping, poisoning, electrocution, road kills, and suffocation have been recognized as human-induced mortality factors (Grinnell et al. 1937, Morrell 1972, Egoscue 1975, Berry et al. 1987, Ralls and White 1995, Standley et al. 1992). The use of pesticides and rodenticides also pose threats to kit foxes. Pest control practices have impacted kit foxes in the past, either directly, secondarily, or indirectly by reducing prey. Invasion and occupation of historical and potential kit fox habitats by non-native red foxes may limit opportunities for kit foxes. Exclusion of kit foxes by competing red foxes, direct mortality, and potential for and parasite transmission all are issues that have not yet been researched.

Recovery actions are ordered in two lists, each of approximately equal priority to the other: a) habitat protection and population interchange, and, b) population ecology and management. Habitat protection and enhancement requires appropriate land use and management. To do so often requires purchase of title or conservation easement, or another mechanism of controlling land use. A high priority is on research to determine appropriate habitat management and other recovery actions. Management actions will protect, maintain, expand and connect natural lands, including refuges and reserves; determine the geographic distribution and genetic makeup; and establish a scientifically valid population monitoring program.

Riparian Brush Rabbit. The riparian brush rabbit (S*ylvilagus bachmani riparius*) is a distinct subspecies of cottontail rabbit that historically lived in riparian areas along the San Joaquin River and the Delta. Unlike other rabbits, the riparian brush rabbit occupies riparian forest that have an ample brushy understory within natural floodplains. These floodplain riparian forests must be attached to suitable upland areas for cover and retreat from annual floods. Historically, this species habitat was throughout the floodplain on the valley floor in the northern San Joaquin Valley including the Delta, but the original forest and floodplain have been reclaimed, cleared, altered, and degraded with less than six percent of the original habitat remaining.

The remaining population of the riparian brush rabbit is restricted to remnant San Joaquin Valley riparian forests with dense brushy understory. This remnant population of riparian brush rabbit is now restricted to 198 acres of remaining native riparian forest along the Stanislaus River in Caswell Memorial State Park and possibly on private property directly across from the Park in southern San Joaquin County. Loss of habitat and declining populations has warranted its listing as a State and Federal endangered species. The ERP has been instrumental in riparian brush rabbit conservation efforts which have concentrated on establishing a new population within the rabbit's historical range at the San Joaquin River National Wildlife Refuge by funding the acquisition of this property. A captive breeding and reintroduction program was undertaken and rabbits were released in 2001.

Riparian Woodrat. The riparian woodrat (*Neotoma fuscipes riparia*) is associated with riparian habitats of the Central Valley floodplain. The small remaining population of riparian woodrat is restricted to remnant riparian forests with dense brushy understory, notably the same 198 acre site as the riparian brush rabbit along the Stanislaus River in Caswell Memorial State Park. The species is also likely to occur on private property in the area. Loss of habitat and declining populations has warranted its consideration as a California Species of Special Concern and as an endangered species.

Greater Sandhill Crane. The greater sandhill crane (*Grus Canadensis tabida*) is found throughout most of the Central Valley in winter and nests in northeastern California and Oregon. Habitats used include seasonal and fresh emergent wetlands, grasslands, and agricultural lands. Much of their nesting habitat has been lost due to conversion to agricultural lands and intensive cattle grazing. One of the objectives of implementing wildlife-friendly agricultural practices is to improve habitat for greater sandhill crane wintering in the Central Valley by providing essential habitat for foraging and roosting. Up to about 2 percent of the population may occur during winter in the San Joaquin River and West San Joaquin Basin from the confluence of the Stanislaus and San Joaquin rivers to Westley, California (Pogson and Lindstedt 1988). Greater sandhill cranes demonstrate a high degree of philopatry to traditional wintering sites and do not readily shift to new areas. This fact makes the loss of habitat from crop conversions, changes in farming practices, urbanization, human disturbance, and changes in land use a concern.

Conservation efforts will implement actions in concert with species recovery strategies, enhance agricultural habitat to improve the abundance and availability of upland agricultural forage (e.g., corn and winter wheat). The restoration of wetlands will give priority to restoring and managing wetland habitat within areas that provide suitable roosting habitat and recreational uses should be avoided or minimized in areas that could disrupt crane habitat use patterns from October-March. A portion of enhanced agricultural lands will be managed to increase forage abundance and availability for cranes and monitoring efforts to determine their use of protected, restored and enhanced habitats in core wintering areas should be completed.

***Tricolored Blackbird*.** The Tricolored Blackbird (*Agelaius tricolor)* is North America's most colonial landbird. Its breeding colonies often teem with more than 50,000 birds, sometimes all settled into a single 10-acre field or wetland to raise their young. Over just the last 70 years, the Tricolored Blackbird population has decreased by more than 80%.

Conservation efforts will conserve habitat, provide research to more thoroughly understand the species' life history, monitor to document population trends and distribution, and educate to enhance public and private landowner awareness and support for conservation efforts.

***Waterfowl*.** California has lost more than 95% of its historic wetlands, largely due to urbanization, flood control and agriculture. As a result, many species have declined from historic levels, and are increasingly dependent on fewer wetlands. Despite these tremendous habitat losses, the Central Valley of California is the most important waterfowl wintering area in the Pacific Flyway, supporting up to 60% of the total Flyway population in some years (Heitmeyer 1989) and higher proportions of certain populations. Food availability is a key factor limiting waterfowl populations during migration and winter (Miller 1986, Conroy et al. 1989, Reinecke et al. 1989), and habitat conditions on the wintering grounds may influence reproductive success (Heitmeyer and Fredrickson 1981, Kaminski and Gluesing 1987, Raveling and Heitmeyer 1989).

ERP supports actions that maintain and restore healthy populations of waterfowl at levels that can support consumptive (e.g., hunting) and nonconsumptive (e.g., birdwatching) uses. Many species of resident and migratory waterfowl will benefit from improved aquatic, wetland, riparian, and agricultural habitats. Conservation actions will include improved seasonal wetlands and floodplain/stream interactions.

Neotropical Migratory Birds. Many of the ERP-funded restoration projects that include riparian restoration have collected information on restoration success; however additional scientific studies are needed to determine appropriate conditions for the germination and establishment of riparian woody plants along the San Joaquin River. Because such a limited amount of riparian habitat remains, compared to historical conditions, certain populations of Neotropical migratory birds, such as yellow warbler, bank swallow, and yellow-billed cuckoo, are in danger of extirpation from the valley floor due to a combination of habitat fragmentation and/or loss, predation, parasitism, and contaminants. Implementation of riparian habitat Stage 2 conservation priorities are needed to protect these species and others similarly affected.

***Bank Swallow*.** The bank swallow (*Riparia riparia*) was once considered to be common throughout California. Today, bank swallows are locally common only in certain restricted portions of their historic range where sandy, vertical bluffs or riverbanks are available for these colonial birds to construct their nest burrows. The bank swallow nests in earthen banks and bluffs, as well as sand and gravel pits. It is primarily a riparian species throughout its North American and Eurasian breeding range.

Conservation efforts will continue to coordinate protection and restoration of channel meander belts and existing bank swallow colonies with other federal and state programs (e.g., participation in planning and implementation of activities associated with the Army Corps of Engineers Sacramento and San Joaquin Basin levee efforts and The Riparian Habitat Joint Venture) that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives.

California Yellow Warbler. The California yellow warbler (*Dendroica petechia*) summers throughout northern California and in the coastal regions of southern California. In recent decades, there has been a marked decline in the breeding population of these birds in both the San Joaquin and Sacramento valleys. Loss of riparian habitat from agricultural and urban development, and brood parasitism by brown-headed cowbirds are believed to contribute to the decline of this species.

Conservation efforts will continue to coordinate protection and restoration of riparian habitat with other federal and state programs that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. As possible, actions will protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat. A portion of restored riparian habitat area will be designed to include riparian scrub communities and, in associated with implementing ERP’s wildlife friendly agriculture program, work with farmers to reestablish native trees, shrubs, grasses and wildflowers on their field edges. As practicable, restore riparian habitats in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

Least Bell's Vireo. The Least Bell's vireo (*Vireo bellii pusillus*) is the westernmost of four subspecies of Bell’s Vireo. Its historical breeding habitat was from the northern end of the Central Valley to Baja California in Mexico with the San Joaquin Valley being the historical center of its breeding range. The species was common to locally abundant in lowland riparian forests of the San Joaquin River (Franzreb 1989). In 1986 it had been extirpated from most of its historical range, including the entire San Joaquin Valley, and numbered just 300 pairs statewide, confined mostly to eight counties south of Santa Barbara. Since listing, Least Bell's Vireo numbers have increased 6-fold, and the species is expanding into its historical range. In 1989, the population size was estimated at 2,000 pairs (Franzreb 1989).

In June of 2005, a Least Bell's Vireo nest was located in an ERP-sponsored riparian restoration site at the San Joaquin River National Wildlife Refuge. A pair returned to the refuge in 2006 and successfully bred, although this was followed by an unsuccessful attempt by an unpaired female in 2007 (Howell 2010). This illustrates the possibility for reestablishment of Least Bell's Vireo as the ERP continues to work towards recovery of the San Joaquin River ecosystem.

Conservation efforts will continue to coordinate protection and restoration of riparian habitat with other federal and state that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. As possible, actions will protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat. A portion of restored riparian habitat area will be designed to include riparian scrub communities and, associated with implementing ERP’s wildlife friendly agriculture program, work with farmers to reestablish native trees, shrubs, grasses and wildflowers on their field edges. As practicable, restoration of riparian habitats will be in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

Swainson’s Hawk. Swainson’s hawks (*Buteo swainsoni*) occur throughout the Central Valley where riparian forest and oak savanna habitats are present. While this species nests in the riparian areas, it forages in upland grassland and croplands. Although Swainson's hawks are not an obligate riparian species, in the San Joaquin Valley its dependency on the availability and distribution of large nesting trees that are close to high-quality foraging habitats results in a preference for riparian forests. Additionally, the agricultural landscape nearest most of the San Joaquin Valley riparian forests is a mix of crops, irrigated pasture, seasonal wetlands and uncultivated grassland habitats, very good foraging areas for this hawk. (See the Delta species section for further species detail).

Conservation actions will focus on the restoration of valley/foothill riparian habitat initially in the Delta. Seasonal wetlands will be designed into occupied habitat areas to provide overwinter refuge for rodents to provide source prey populations during spring and summer. Actions will include a percentage of agricultural lands to be enhanced under the ERP in the Delta, Sacramento River, and San Joaquin River Regions to increase forage abundance and availability within 10 miles of occupied habitat areas. Efforts will manage lands purchased or acquired under conservation easements that are occupied by the species to maintain or increase their current population levels. As practical, actions will manage restored or enhanced habitats under the ERP to maintain desirable rodent populations and minimize potential impacts associated with rodent control.

Yellow-billed Cuckoo. In California’s Central Valley, the western yellow-billed cuckoo (*Coccyzus americanus*) depends on riparian vegetation for cover, foraging, and breeding (RHJV 2000). Within riparian vegetation, dense, low, shrubby vegetation is a particularly important habitat component (Dunn and Garrett 1997, Brown 1993, RHJV 2000). In addition, landscape attributes such as patch size and surrounding land uses affect western yellow-billed cuckoo populations. Populations of western yellow-billed cuckoo persist best in large blocks of riparian forest (20–80 ha and often more than 300 ft wide) of meandering riparian zones (Halterman 1991).

Conservation efforts will continue to coordinate protection restoration and enhancement of large, contiguous areas of riparian and wetland habitat with other federal and state programs that could affect management of occupied and historic habitat areas to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. These habitat areas should maintain a great diversity in composition, density and make-up. As possible, actions will protect existing suitable riparian habitat corridors from potential future changes in land use or other activities that could result in the loss or degradation of habitat. A portion of restored riparian habitat area will be designed to include riparian scrub communities and, associated with implementing ERP's wildlife friendly agriculture program, work with farmers to reestablish native trees, shrubs, grasses and wildflowers on their field edges. As practicable, restoration of riparian habitats will be in patch sizes sufficient to discourage nest parasitism by brown-headed cowbirds.

California Red-legged Frog. The California red-legged frog (*Rana draytonii*) historically occurred throughout the Central Valley and now exists only in small isolated populations scattered throughout its historical range. Major factors for the decline of the California red-legged frog include degradation and loss of critical wetland breeding habitat and adjacent terrestrial habitats. Stressors from human activities like agricultural practices (disking, mowing, burning, and pest control) also contribute to the population decline. Restoration of suitable aquatic, wetland, and riparian habitats and reduced mortality from predators will be critical to achieving recovery of the California red-legged frog.

Conservation measures will protect, restore, and enhance suitable aquatic, wetland, and riparian and upland habitats will benefit the recovery of the red-legged frog. Efforts to manage invasive species such as the bullfrog will also be carried out where necessary to benefit the recovery of the species.

Foothill Yellow-legged Frog**.** The foothill yellow-legged frog (*Rana boylii)* has disappeared from much of its range in California (possibly up to 45 percent). Water released from reservoirs, that washes away eggs and tadpoles and forces adult frogs away from the streams leaving them more vulnerable to predators, is a serious problem for frogs. Air-borne pesticides from the vast agricultural fields of the Central Valley are also likely to be a primary threat. Introduced fish also stress frog populations by consuming eggs and tadpoles, and introduced bullfrogs compete for food and eat the frogs. Habitat loss, disease, introduced crayfish, stream alteration from dams, mining, logging, and grazing, are also threats to this frog.

Conservation measures will protect, restore, and enhance suitable aquatic, wetland, riparian and upland habitats that will benefit the recovery of the species; and feasible actions will be implemented to address concerns with disease, introductions of non-native trout, airborne contaminants, wildland fires, fire suppression activities, climate change, livestock grazing, water developments, and recreational activities. Efforts to manage invasive species such as the bullfrog will also be carried out where necessary to benefit the recovery of the species.

***California Tiger Salamander*.** The California tiger salamander (*Ambystoma californiense*) uses burrows for aestivation and shelter during the warm, dry months of summer and autumn. Because California tiger salamanders dig poorly, the burrows of small mammals are essential. Their habitat is usually within grassland or oak savannah, and sometimes oak woodland.

Conservation actions will maintain existing populations in the Bay-Delta, protect and restore existing and additional suitable aquatic, wetland, and floodplain habitats and reduce the effect of other factors that can suppress breeding success.

***Western Spadefoot Toad*.** Optimal habitat for the western spadefoot toad (*Spea hammondii*) is grasslands with shallow temporary pools. Western spadefoot toads are rarely found on the surface as most of the year is spent in underground burrows up to 0.9 m (36 in) deep (Stebbins 1972), which they construct themselves. Breeding and egg laying occur almost exclusively in shallow, temporary pools formed by heavy winter rains. During dry periods, the moist soil inside burrows provides water for absorption through the skin (Ruibal et al. 1969, Shoemaker et al. 1969). Dispersal of post-metamorphic juveniles from breeding ponds often occurs without rainfall.

Conservation actions will maintain the species in the Bay-Delta by protecting and restoring existing and enhancing additional suitable aquatic, wetland, and floodplain habitats; and by reducing the effect of other factors that can suppress breeding success. To stabilize and increase its population, efforts will focus on the elimination of non-native predator species from historic habitat ranges. Additionally, actions will increase suitable habitat and maintain clean water supplies to meet the needs of this species.

Giant Garter Snake. The Draft Recovery Plan for the Giant Garter Snake (*Thamnophis gigas*) (USFWS 1999) identified several potential repatriation (reintroduction) sites or areas for giant garter snakes within the San Joaquin Valley Region: Merced National Wildlife Refuge, San Joaquin River National Wildlife Refuge, and Madera Ranch. Increased habitat quality and area in these locations could potentially contribute to the long-term viability of the giant garter snake population by improving survival during periods of extended flooding. In addition, including improvements to and maintenance of suitable agricultural infrastructure (e.g., ditches, drains, canals, levees) as part of the ERP conservation priorities to enhance wildlife habitat values associated with agricultural lands may also be important because giant garter snake has had to adapt to using these artificial features (CALFED 2000a). (See the Delta species section for further species detail).

Conservation actions will restore wetland and upland habitats adjacent and connected to occupied habitat. Action will restore fresh emergent wetland habitat adjacent to and connected with existing non-tidal emergent wetlands already used by giant garter snake, providing essential forage habitat and refuge from predators and frequent flood events, and creating dispersal corridors by linking habitat areas.

Western Pond Turtle. The western pond turtle (*Clemmys marmorata*) originally ranged from northern Baja California, Mexico, north to the Puget Sound region of Washington. They occur in both permanent and intermittent waters, including marshes, streams, rivers, ponds and lakes, favoring habitats with large numbers of emergent logs or boulders where they aggregate to bask.

Conservation action includes maintaining and expanding the abundance and distribution of *C. marmorata* by maintaining or expanding its existing populations by improving stream channel, floodplain riparian processes, and reducing predator species.

Valley Elderberry Longhorn Beetle. The valley elderberry longhorn beetle (*Desmocerus californicus dimorphus*) is dependent on its host plant, elderberry, to meet its life history requirements (USFWS 1984b). Flood management practices in the San Joaquin Valley have contributed to a substantial decline in the availability and quality of riparian habitat used by this species and its host plant.

Conservation actions will focus on riparian restoration projects that maintain and restore connectivity among riparian habitats occupied by the valley elderberry longhorn beetle within its historical range in the Delta and along the Sacramento and San Joaquin Rivers and their major tributaries.

Vernal Pool Species. Vernal pools are seasonally flooded depressions found on ancient soils with an impermeable layer such as a hardpan, claypan, or volcanic basalt. The impermeable layer allows the pools to retain water much longer then the surrounding uplands; nonetheless, the pools are shallow enough to dry up each season. Vernal pools often fill and empty several times during the rainy season. Only plants and animals that are adapted to this cycle of wetting and drying can survive in vernal pools over time. Many of these are native species endemic to vernal pools or related wetland habitat.

Conservation actions for vernal pool species include ERP actions directed towards protecting, enhancing, and restoring suitable vernal pool and associated grassland habitat within these species historic ranges. ERP actions will include the coordination of these actions with other federal and state programs to avoid potential conflicts among management objectives and identify opportunities for achieving multiple management objectives. Conservation effort will include conducting surveys to identify suitable habitat areas, including enhanced and restored habitats, for establishment of additional populations of vernal pool species in the Delta and its watershed and implement species introductions to establish additional populations as appropriate. Lands will be appropriately maintained when purchased or acquired under conservation easements that are occupied by vernal pool species to maintain or increase current population levels and enhance occupied habitat areas.

SECTION 4: Adaptive Management

Adaptive management is defined in the Delta Reform Act (Water Code Section 85052) as "a framework and flexible decision-making process for ongoing knowledge acquisition, monitoring, and evaluation leading to continuous improvements in management planning and implementation of a project to achieve specified objectives". An adaptive management approach provides a structured process that allows for taking action under uncertain conditions based on the best available science, closely monitoring and evaluating outcomes, and re-evaluating and adjusting decisions as more information is learned.

Uncertainty in this context may include: 1) the inability to predict the future state of dynamic systems; 2) the degree to which future conditions depend on unpredictable or unforeseen external drivers; 3) incorrect or incomplete information about underlying processes that make predicting outcomes difficult; or 4) disagreement about the underlying processes based on alternative interpretations of data. Uncertainties in ecosystem management are compounded by uncertainties related to future conditions such as climate change, population growth, water supply, and likelihood of catastrophic earthquakes. "Uncertainty is pervasive and although absolute solutions are unlikely to be found, science will continue to be a main source of information for policymaking. Building and maintaining a scientific infrastructure to help meet future challenges is essential to any sustainable way forward" (Healey et al. 2008).

Due to the uncertainties inherent in our understanding of the function of dynamic ecosystems, the effects of restoration and management actions cannot always be accurately predicted. In developing this Conservation Strategy for implementing the ERP through year 2030, the ERP implementing agencies have adopted a long-term perspective. This long-term perspective includes taking an adaptive management approach in which new information is taken into account as it is learned over time.

I. A Three Phase Adaptive Management Framework

The adaptive management process described in the ERP Strategic Plan (CALFED 2000c) and several other previously developed frameworks (e.g., Christensen et al. 1996, Stanford and Poole 1996, Atkinson et al. 2004, Abal et al. 2005, Healey 2008, Dahm et al. 2009, Williams et al. 2009, DSC 2012) provide the basis for the approach described in this strategy. While differences among the various frameworks exist, they generally contain three broad phases: *Plan*, *Do*, and *Evaluate and Respond*. During implementation of Stage 2, the ERP Implementing Agencies will use the three phase (nine-step) adaptive management framework depicted in Figure 7, which is consistent with the framework described in the Final Staff Draft Delta Plan (DSC 2012). A common approach to adaptive management and terminology is incorporated to facilitate reviews of consistency with the Delta Plan for potential covered actions that may stem from the ERP Conservation Strategy.

Figure 7: A Three Phase (Nine-step) Adaptive Management Framework (DSC 2012). The shading represents the three broad phases of adaptive management (Plan, Do, and Evaluate and Respond), and the boxes represent the nine steps within the adaptive management framework. The circular arrow represents the general sequence of steps. The additional arrows indicate possible next steps for adapting (for example, revising the selected action based on what has been learned).

Adaptive management can take two forms: active and passive. Active adaptive management is experimental, involving manipulations intended to achieve conservation goals but also to improve knowledge. Through passive adaptive management a best management option is selected on the basis of the current beliefs about system dynamics and this option is fine-tuned in relation to experience. While passive adaptive management is not experimental, it is nevertheless approached from a scientific perspective to improve knowledge and adapt strategies during project implementation. The form of adaptive management (active vs. passive) most appropriate to apply to a given action depends on the scope of the measure and its degree of reversibility.

The adaptive management framework can be implemented at both program (e.g., implementing ERP grant program) and project (e.g., individual grant project) levels.

However, given the duration of individual grants (three years) and the time necessary to plan, implement, and evaluate restoration projects, it may not be possible, in many instances, to complete the adaptive management process in the context of a single grant. A previous evaluation of restoration projects funded through the ERP found that the steps associated with the Plan and Do phases (steps 1 – 6) of the adaptive management framework were fairly well represented (Kleinschmidt and Jones & Stokes 2003). However, the steps associated with the Evaluate and Respond phase (steps 7 – 9) were highly underrepresented, or not represented at all (Kleinschmidt and Jones & Stokes 2003). At the program level, it is necessary to link the individual projects and use what is learned to inform future decision-making (Kleinschmidt and Jones & Stokes 2003).

Step 1: Define/Redefine the Problem

The first step in the adaptive management process is to clearly define a problem or set of problems that will be addressed. Defining a problem usually requires determining the spatial and temporal bounds of the problem and the ecological processes, communities, species, and/or interactions affected by the problem. A clear problem statement should link directly to program goals, which in turn are linked to specific objectives and conservation priorities. Volumes I and II of the ERPP (CALFED 2000a, 2000b) and Sections 1 through 3 of this document define many of the key problems that affect the health of the Bay-Delta ecosystem.

Step 2: Establish Goals and Objectives

Once a problem has been defined, it is necessary to articulate clear goals and tangible, measurable objectives. Goals are broad statements that provide the basis for a vision of a desired future condition. Objectives are specific, often quantitative, statements of outcomes that reflect the goals that the program is expected to achieve. Objectives need to be measurable, to allow for assessments of progress toward their achievement, and so performance that deviates from objectives may trigger a change in management direction (Williams et al. 2009).

The ERP Strategic Plan (CALFED 2000c) defines broad goals and objectives for the Bay-Delta ecosystem. This Conservation Strategy describes a suite of conservation priorities relevant to Stage 2 of ERP's implementation, which are designed to make progress towards the Program's strategic goals (CALFED 2000c). Activities funded through the ERP grant program or directed actions must be designed to achieve or contribute to achieve one or more of the Program's objectives.

Volume II of the ERPP (CALFED 2000b) defines targets and programmatic actions for the ecological management zones and units that comprise the larger Bay-Delta ecosystem. Targets are quantitative or qualitative statements of what is needed in terms of the quantity or quality of a particular attribute to meet the objectives. The ERP's foundational documents (refer to Appendix E), which identified the rationale for the program's goals, objectives, and targets, were based on scientific principles and the best information available at the time.

Step 3: Model Linkages Between Objectives and Proposed Action(s)

Models formalize and apply current scientific understanding, as well as provide a venue through which to identify areas of uncertainty, identify possible restoration actions, develop expectations, assess the likelihood of success, define monitoring needs, and evaluate tradeoffs associated with different management actions. Models are extremely valuable for formalizing the link between objectives and proposed actions to clarify how and why each action is expected to contribute to objectives. Examples of the types of models that may be employed include, but are not limited to, conceptual, statistical, and process models. Additional discussion of the roles of conceptual models is provided in the ERP Strategic Plan (Chapter 3 and Appendix B, CALFED 2000c).

A formalized approach to the development of conceptual models has been developed under the auspices of the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP), a component of ERP. Two types of conceptual models have been generated through this process: species life history models and ecosystem models. The ecosystem models have been categorized into processes, habitats, and stressors. Additional information regarding these Delta conceptual models, and the models themselves, is available online at: http://www.dfg.ca.gov/erp/conceptual_models.asp. During Stage 1, the ERP also funded the development of an ecological flows modeling tool for the Sacramento River (Sacramento River Ecological Flows Tool [SacEFT]), and recently provided additional funding to develop a similar modeling tool for the Delta. The IEP also developed a suite of conceptual models over the course of the pelagic organism decline (POD) investigation that revolve around natural and anthropogenic drivers that affect ecological change such as the observed pelagic fish declines (Baxter et al. 2010). Additional conceptual and quantitative models are being developed by other agency, academic, and non-government organization (NGO) scientists for use in improving understanding of the Delta and upstream ecosystems. These are likely to be valuable for identifying improved approaches to regional restoration and other management actions.

The fundamental approach to modeling, implemented through DRERIP, is a "driver-linkage-outcome" format that uses deterministic models of ecosystem components linked together with cause-and-effect relationships of interacting variables and outcomes. There are numerous drivers and intermediate outcomes leading to ultimate outcomes in the analysis. Conceptual models are used to improve understanding of the overall environment, and the relationships between its components, resulting in better predictability regarding the magnitude and certainty of the effects of potential restoration actions. These effects include positive or negative effects that may or may not be anticipated, thereby providing for scientifically defensible courses of action for restoration or land and water management.

The development of regional landscape-scale conceptual models would enhance our restoration planning activities and help guide programmatic decisions from a more holistic scientific understanding (e.g., tool for evaluating/selecting grant applications pertaining to restoration actions). The spatial and temporal scale of the conceptual model(s) must be sufficiently large to encompass an understanding of the physical and ecological context of the processes that determine the current condition (Hermoso et al. 2012). This is important because environmental degradation observed at local spatial scales is often the result of processes that occur at larger spatial scales. Landscape-scale conceptual models could also help to define a guiding image for restoration, as well as providing a framework for enhanced coordination/integration among the various entities implementing these activities. The guiding image describes the dynamic, ecologically healthy environment that could exist at a given site (Palmer et al. 2005). This would also aid in developing common expectations about restoration progress, outcomes, uncertainty, and cost. The development of such models should occur through cooperation with the Delta Science Program, IEP, academic institutions, and other appropriate partners (DSC 2012).

Information obtained through historical ecology studies can inform the landscape conceptual model development process and other components of restoration planning. The Aquatic Science Center, a Joint Powers Authority created by the SWRCB and Bay Area Clean Water Agencies that is managed and staffed by San Francisco Estuary Institute (SFEI), has completed mapping and documenting Delta habitat patterns and characteristics as they existed prior to significant Euro-American modification. A key goal of this ERP funded Historical Ecology Study is to inform restoration planning in the Delta by relating habitats, habitat mosaics, and landscapes to ecological function. The integration of the historical perspective in this study with current planning efforts could help to define design criteria and suitable locations for restoration actions.

Ongoing management of the ERP during Stage 2 will continue to be focused on using and updating conceptual models, as well as other model types (e.g., exploratory simulation models), to refine the design of conservation strategies for each geographic area and/or watershed and associated monitoring approaches.

Step 4: Select Action(s) (Research, Pilot, or Full-scale) and Develop Performance Measures

A summary of the conservation priorities for Stage 2 (2008 – 2030) of the implementation of the CALFED ROD is included in the relevant sections of this document. Ideally, proposed conservation priorities should be linked to clear goals and objectives via a landscape-scale conceptual model (discussed above). It is important to note, however, that the spatial and temporal scales for implementing ecosystem conservation priorities can be smaller than those considered during the planning phase, given constraints related to restoration opportunities and funding necessary to pursue them (Hermoso et al. 2012).

ERP has implemented a transparent process with multiple levels of review to select projects through the proposal solicitation process (PSP). For example, all completed proposals submitted in response to the 2010/2011 Proposal Solicitation Package underwent administrative review, external scientific review, ERP Implementing Agency Managers review for project selection, and Delta Stewardship Council review. Funding recommendations were based on the quality of the proposal, its ability to meet ERP strategic goals, and the amount of available funds. The reviews and funding recommendations were made available for public comment through the ERP PSP website. Following public comment, the Director of CDFW made final recommendations for final funding approval and CDFW prepared grant agreements for approved projects.

During Stage 1, projects were selected in an open process where project proponents submitted proposals in accordance with the general program objectives. Although such a process encourages new thinking at a project level, there was no systematic strategy to assure that progress was being made toward the overall ERP goals. In Stage 2, the knowledge and results from the Stage 1 projects are being used, in combination with ERP strategic goals and conservation priorities, and other efforts listed in Appendix B such as species recovery plans, to determine areas of ecological focus. Projects to be implemented within these areas of focus are selected through a more focused proposal solicitation process and/or specific directed actions. These actions will also be selected based on their likelihood of making progress toward ERP strategic goals.

It is anticipated that through this more focused approach, the projects will benefit from closer interaction between the ERP, resources agencies, and the project proponents concerning rationale, and the projects' expected and actual contribution to program progress. This will improve our ability to evaluate the cumulative contribution of ERP actions toward overall program progress. By enhancing coordination among various projects, ERP can improve the value of individual projects by determining the interrelationships of the projects and encouraging interaction among project proponents. CDFW maintains a service contract with the University of California, Davis for access to peer review services, which is used to support the proposal solicitation process.

Through the DRERIP planning effort, an Adaptive Management Planning Team (AMPT) consisting of agency technical staff and external scientific advisors was established and tasked with developing a science-based procedure for evaluating proposed restoration actions. The procedure developed by the AMPT consists of three elements: conceptual models (discussed above), an Action Evaluation Procedure, and a Decision Support Tool. The Action Evaluation Procedure represents a standardized protocol for evaluating the worth, risk, reversibility, and opportunity for learning of proposed actions based on information contained in conceptual models. The results from the Action Evaluation Procedure are then evaluated using a DRERIP Decision Tree (Figure 8) to assign prospective actions to the following adaptive management categories: 1) discard the action; 2) pursue it as targeted research; 3) initiate a pilot/demonstration project; or 4) initiate full-scale implementation.

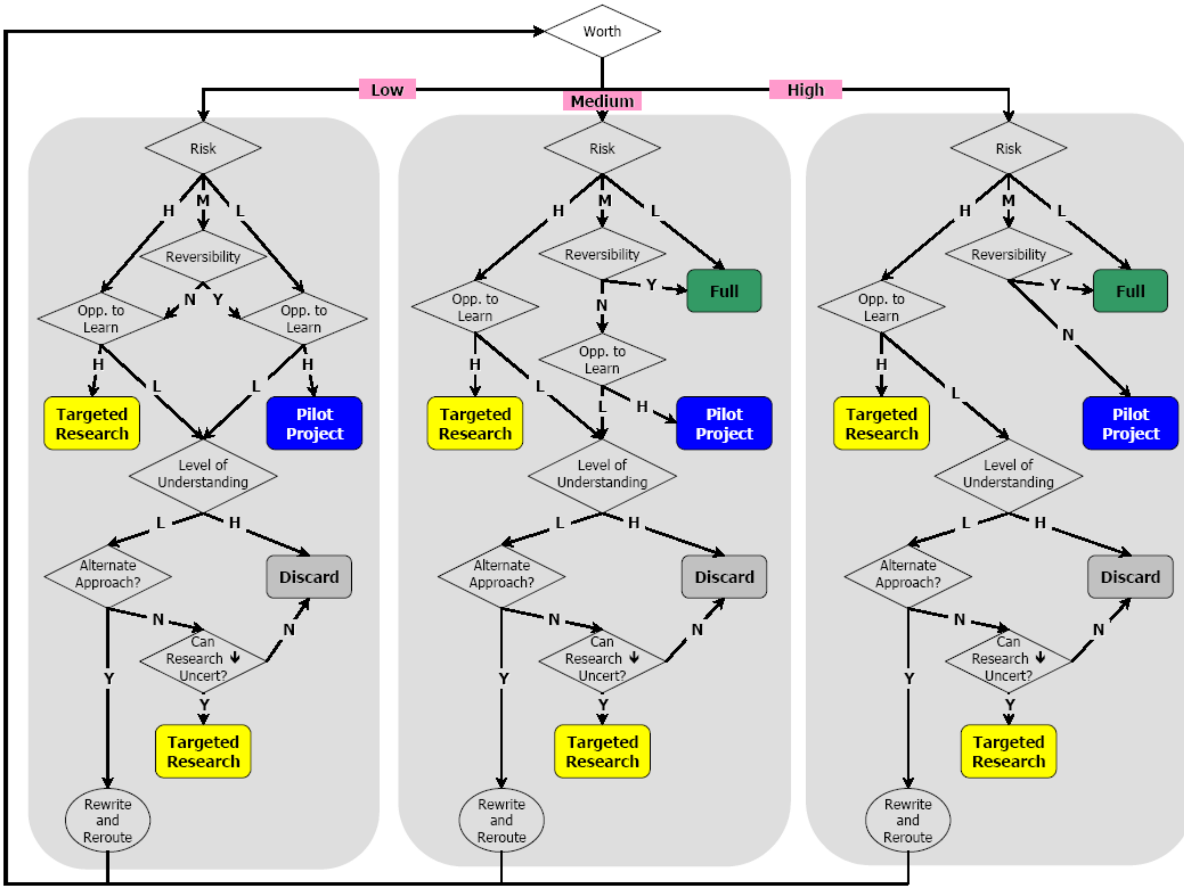

Figure 8: DRERIP Decision Tree for routing proposed actions based on the results of the Action Evaluation Procedure (DiGennaro, 2010).

Additional information regarding the Action Evaluation Procedure and Decision Support Tool is available online at: http://www.dfg.ca.gov/ERP/scientific_evaluation.asp. The evaluation process and decision support tools are particularly relevant to this step in the adaptive management process because it allows for thorough documentation of rationales for management and project-funding decisions, which in turn, facilitates the timely revision of assumptions and incorporation of new scientific information into the models. It also promotes transparency, standardization, and documentation in decision-making to policymakers and the interested public.

Performance Measures – A key component of an adaptive management framework is the identification of measurable outcomes and associated performance measures that are linked to programmatic objectives via models. Measurable outcomes and accurate and operational performance measures are critical components of the adaptive management process in order to:

- document desired and anticipated outcomes following implementation of specific actions;
- help to define the monitoring required to evaluate the outcomes of those actions; and
- track progress towards achieving stated objectives (Dahm et al. 2009).

Performance measures are discussed further in Section II (Performance Measures) of this chapter.

Step 5: Design and Implement Action(s)

The design and implementation of action(s) includes clearly describing specific activities that will occur under the selected action(s) and how they will link to the monitoring plan (described below). Design includes creating a plan for both implementing and monitoring responses from the actions. The design of the action(s) should be informed by existing uncertainties, and should be directly linked to meeting the goals and objectives. The design step also includes developing a budget and identifying adequate funding to carry out the action(s) and the associated monitoring and assessment for an appropriate period. At the scale of individual grant projects and directed actions, project planning and design will rely ultimately on the principal investigators (contractors/grantees). However, technical staff from the ERP Implementing Agencies and peer review associated with the proposal solicitation process will provide an interface for effective science, coordination, and management.

Step 6: Design and Implement Monitoring Plan

The design and implementation of a monitoring plan occurs in parallel with the effort to design and implement an action(s). Monitoring is a key component of the science-based, adaptive management strategies needed to meet the goals and objectives of the ERP. It is critical to monitor the implementation of ERP actions to gauge how the ecosystem responds to management interventions. Monitoring provides the data necessary for tracking ecosystem health, for evaluating progress toward restoration goals and objectives, and for evaluating and updating problem statements, goals and objectives, conceptual models, and restoration actions (CALFED 2000c).

There are several types of monitoring that may be conducted in association with implementation of the selected actions during Stage 2:

- Implementation (compliance) monitoring (stipulations in grant agreements)
- Effectiveness (performance) monitoring (measuring achievement of targets), Mechanistic monitoring (targeted research - testing the understanding of linkages in the conceptual model)
- System-level monitoring (holistic and long-term).

These types of monitoring can measure and communicate various types of information, including administrative/inputs (e.g., dollars spent or projects funded), compliance/outputs (e.g., acres exposed to tidal action), and effectiveness/outcomes (e.g., did an action achieve its expected outcome) (DSC 2012). The monitoring plan must include an integrated set of monitoring metrics that can be integrated and summarized to inform the ERP Implementing Agency Managers, other decision makers, and the public as described in step eight, *Communicate Current Understanding*. Additional information regarding monitoring plan design and constraints associated with monitoring the effectiveness of grant-funded actions is provided in Section III (Monitoring Program).

Step 7: Analyze, Synthesize and Evaluate

Implicit in the adaptive management framework is the expectation that the consequences of restoration or other actions will be monitored and assessed to determine whether and how such actions are having the intended effects. These activities are essential steps supporting the feedback loops that are foundational components of adaptive management. Performance measures serve as a key component of this process. Assessments are a crucial step in making monitoring useful, in that they convert data to the information needed to evaluate program performance. The evaluation should address questions, such as: how have conditions changed, have they changed in expected ways, and what might have caused deviations from the expected trajectory (Dahm et al. 2009). Each grant recipient has specific reporting requirements. ERP will strive to create stronger linkages among the projects it funds to enhance opportunities for integrative assessments across projects. A number of processes are underway to improve efforts related to analysis, synthesis and communication of information, including IEP's Management, Analysis, and Synthesis Team (MAST); California Water Quality Monitoring Council (CWQMC); Unified Monitoring, Assessment and Reporting Program (UMARP); Comprehensive Assessment and Monitoring Program (CAMP); and the Delta Science Plan. ERP staff will seek opportunities to coordinate its activities with these efforts, as appropriate.

Step 8: Communicate Current Understanding

Communication of current understanding gained through assessment, synthesis, and evaluation of implemented actions and monitoring is an essential step for informing and equipping policy makers, resource managers, stakeholders, and the public to appropriately respond and adapt. Reporting of performance measures on the ERP website and potentially other venues (e.g., CWQMC's internet portals) will serve as an important form of communication. As appropriate, these communication activities should be coordinated with IEP, Delta Science Program, the BDCP process, and other entities. The information communicated should be technically sound, well synthesized, and translated into formats appropriate for target audiences (e.g., public, legislature, resource managers). The information will be distributed to the ERP Implementing Agency Managers (ERPIAMs) and others directly involved in the adaptive management process and to those interested in the outcome of the action(s). This step is also a critical component of public outreach activities. Public funds will finance much of the activities implemented during Stage 2, so it is important that the public understands the justifications, benefits, and outcomes of ecosystem restoration activities. Additionally, results should be published in technical, peer-reviewed journals to provide external review, transparency, and accessibility, in instances where the results warrant this level of communication. CDFW maintains a service contract with the University of California, Davis for coordination of peer review services for final reports and other needs (e.g., proposals).

Step 9: Adapt

Restoring and managing ecosystems requires a flexible management framework that can generate, incorporate, and respond to new information and changing conditions. The key to successful adaptive management is learning from restoration and management actions and incorporating new information into the planning and management process. Problem statements, goals, objectives, conceptual models, quantified targets, and the conservation priorities or other management actions that flow from them must be re-evaluated and, if appropriate, they should be revised to reflect the most current information and understanding (CALFED 2000c).

The ERP Implementing Agencies are ultimately responsible for decisions that are implemented concerning the ERP. The ERP Implementing Agencies execute the ERP through regular meetings where program priorities are discussed, annual program plans and proposal solicitation packages are developed that reflect those priorities, grant proposals are selected and funded, amendments to ongoing ERP-funded projects are considered, and annual progress towards meeting program milestones is assessed. The ERP Implementing Agency Managers and technical staff are responsible for evaluating ERP implementation and effectiveness on an ongoing basis. Such reevaluation and revision is essential to ensure that implemented actions are achieving their objectives efficiently and to prevent wasting resources on actions that do not contribute toward achieving objectives. The Delta Independent Science Board, through its mandate to "…provide oversight of the scientific research, monitoring, and assessment programs that support adaptive management of the Delta through periodic reviews of each of those programs…" (Water Code 85280[a][3]) may serve as a venue for external scientific review of the program.

II. Performance Measures

Performance measures are used to translate program goals and objectives into measurable indicators of progress. Performance measures are placed into three general types:

- Administrative performance measures - summarize progress toward completing administrative actions and describe resources (e.g., funds, personnel, projects) focused on a particular subject.
- Driver performance measures (referred to as output performance measures in the Final Staff Draft Delta Plan [DSC 2012]) - evaluate the factors that may be influencing outcomes and include tracking on-the-ground implementation of management actions (e.g., acres of habitat restored) and natural phenomena outside of management control (e.g., floods, earthquakes).
- Outcome performance measures - evaluate ecosystem responses to management actions and/or natural drivers.

The distinction between performance measure types is not rigid. For example, an outcome performance measure for one program objective may represent a driver performance measure for another program objective.

ERP staff are working with other programs to define a suite of performance measures to assess progress toward achieving common goals related to ecosystem restoration and recovery of at-risk species. Such an effort is likely to require the development and evaluation of performance measures at multiple scales, for example:

- Project-level – evaluate outcomes of a specific action;
- Program-level – evaluate outcomes pertinent to a specific program (e.g., ERP); and
- System-level – evaluate outcomes associated with actions implemented by multiple programs and natural processes.

The Final Staff Draft Delta Plan (DSC 2012) identifies a number of outcome performance measures pertinent to ecosystem restoration that correspond with our definition of system-level measures, for example, progress toward achieving the State and Federal “doubling goal” for natural production of Central Valley salmonids. Given the diverse array of factors that affect the sustainability of salmonid populations in the Central Valley, progress toward achieving the “doubling goal” will involve actions on the part of multiple agencies/organizations, working in the context of changing natural processes outside of management control. Restoration actions must be considered in the context of the species’ life cycle, and at both site-specific and system-wide scales. Given that so much of the Chinook salmon life cycle occurs outside of the Delta, and survival in these other environments can be highly variable, even major improvements in Delta conditions would be unlikely to give a clear signal in population level abundance data until many years have passed (Bradford et al. 2005, as cited in Williams 2010). Therefore, additional outcome measures that focus on attributes that are potentially more useful for assessing effectiveness of specific actions in the Delta will be needed.

For the purpose of presenting an example of potential performance measures that could be evaluated at each of the scales identified above, we use the following action:

- Restore riverine and flooding processes to McCormack-Williamson Tract by breaching the Mokelumne River levee and degrading the entire southwest levee.

The McCormack-Williamson Tract is located downstream of the confluence of the Mokelumne and Cosumnes rivers. The action is intended to implement flood control improvements in a manner that benefits aquatic and terrestrial habitats, species, and ecological processes. While the action is designed to achieve numerous objectives (Winternitz 2011), we focus here on the following objective: promoting natural flooding processes and restoring seasonal floodplain in order to enhance rearing habitat for juvenile Chinook salmon.

ERP funds and/or implements actions for the purpose of meeting or contributing to the Program’s strategic goals and objectives (refer to CALFED 2000c). In this instance, the action is relevant to the following ERP strategic goals and objectives.

- Goal 1: Achieve recovery of at-risk species
  - Objective: Recover Central Valley salmonids
- Goal 2: Rehabilitate natural processes
  - Objective: Reestablish floodplain inundation of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional floodplain habitat
- Goal 4: Protect and/or restore functional habitat types
  - Objective: Restore large expanses of major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes

The action of restoring riverine and flooding processes to McCormack-Williamson Track would be consistent with the following floodplain conservation priorities:

- Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats including freely meandering reaches (Goal 2, Conservation Priority 6);
- Manage floodplain habitats to enhance seasonal shallow water benefits for native fish and wildlife, including the Yolo and Sutter bypasses (Goal 4, Conservation Priority 4).

For the purposes of this example, the aspects of this action pertinent to Chinook salmon focus primarily on the portion of its life cycle associated with survival of fry migrants as they pass through the Delta. A number of drivers influence the probability of fry migrants successfully passing through the Delta and transitioning to larger migrants entering the bays. Figure 9 reflects current understanding regarding drivers that exert either positive or negative pressure on this transition probability (outcome).

According to the Chinook salmon life history conceptual model (Williams 2010) in figure 9, floodplains exert a positive influence on the transition probability through enhanced growth (relationship is characterized as having a high level of understanding, importance, and predictability) and reduced predation (relationship is characterized as having a high level of understanding, and medium level of importance and predictability). The floodplain conceptual model (Opperman 2012) in figure 10 identifies the following drivers as having a positive influence (high level of importance and understanding) on juvenile salmon rearing and growth: zooplankton and macroinvertebrate abundance (i.e., prey availability), interannual flood frequency, duration of inundation, and drainage connectivity.

Sommer et al. (2001b, 2005) and Jeffres et al. (2008) demonstrated that juvenile Chinook salmon rearing on floodplains in the Yolo Bypass and Cosumnes River, respectively, grew faster and achieved larger sizes than fish rearing in the main river. Increased prey abundance, warmer water temperatures, and reduced water velocities were identified as habitat characteristics that could account for the increased growth

(Sommer et al. 2001a, 2001b). The increase in rearing habitat provided on inundated floodplains should also create more refuges for juvenile fish and reduce the probability of encounter with a predator (Sommer et al. 2001b, 2005). In addition, studies suggest phytoplankton, zooplankton, and other organic material transported from the Yolo Bypass (Jassby and Cloern 2000; Müller-Solger et al. 2002; Sommer et al. 2004, Lehman et al. 2008) and Cosumnes River floodplains (Ahearn et al. 2006) enhance the food web of the San Francisco Estuary.

A preliminary suite of performance measures that could be used to assess the effectiveness of this action at the project-level and related measures relevant to programmatic (i.e., ERP) and system-level evaluations is presented in Table 3. This is not meant to represent a comprehensive list, but rather to provide an illustrative example with the understanding that further refinement, development, peer review and coordination with other programs would be required prior to implementation.

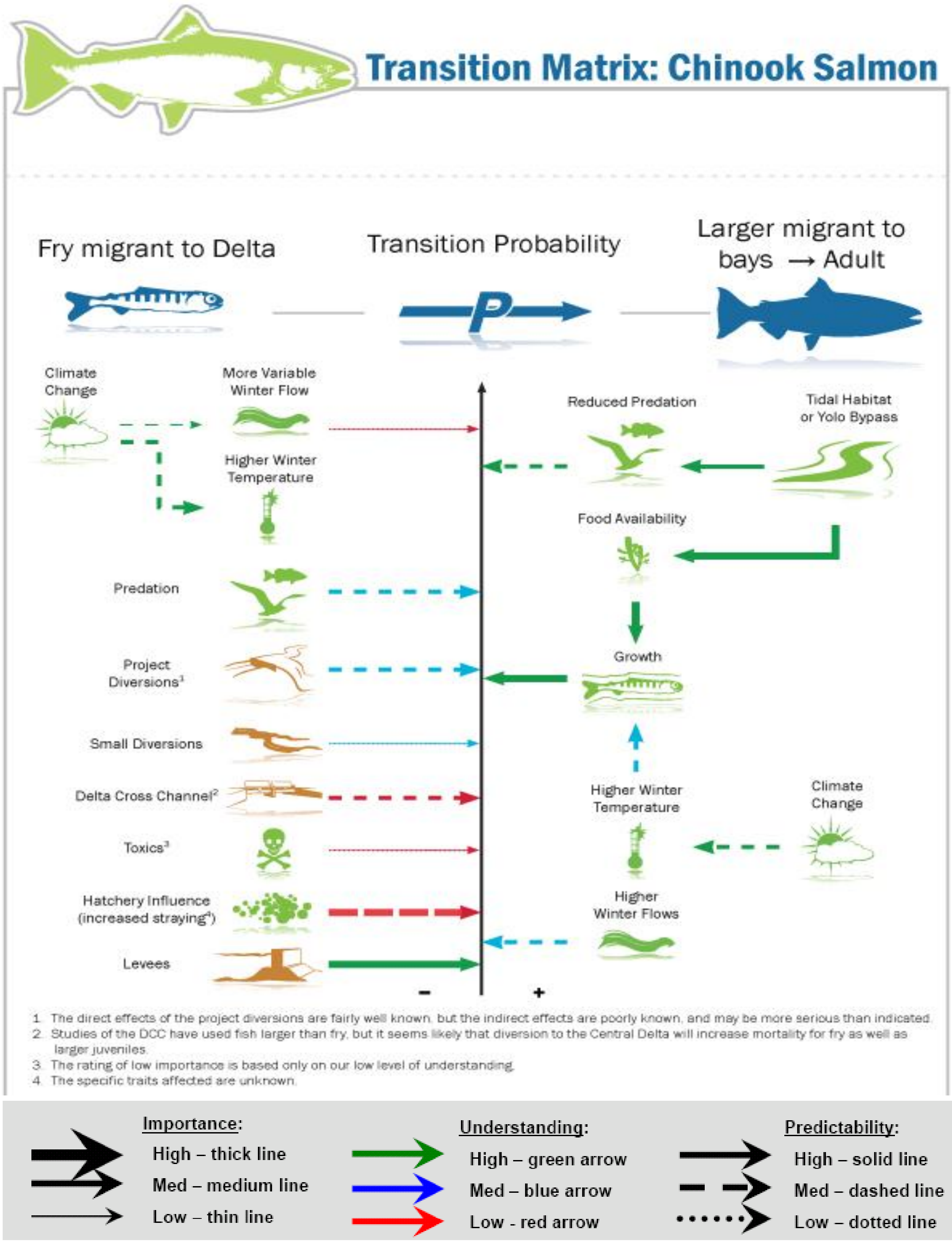

Figure 9: Factors influencing the probability of salmon fry entering the Delta transitioning to larger migrants entering the bays (Williams 2010). Factors on right side of figure exert a positive (+) influence on transition probability, while those on left exert a negative (-) influence.

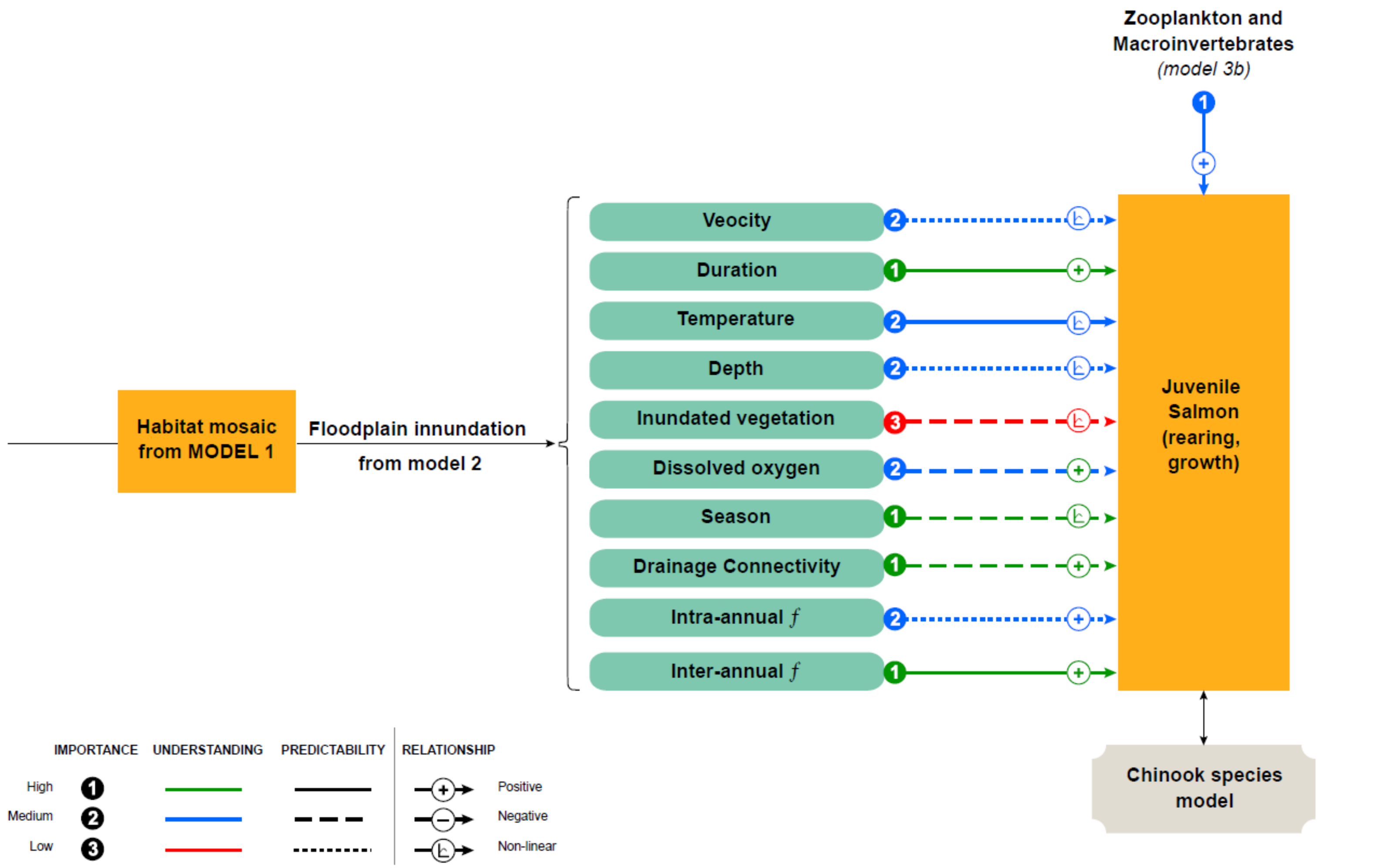

Figure 10: Model 3C: factors that influence juvenile Chinook rearing on inundated floodplains (Opperman 2012).

Table 3: An illustrative example of a partial suite of performance measures that would evaluate effectiveness of restoring riverine and flooding processes at the McCormack-Williamson Tract in order to enhance rearing habitat for juvenile Chinook salmon, as well as related efforts at the programmatic and system-levels.

Type	Performance Measure	Target	Metric
Project-Level (Restore riverine and flooding processes to McCormack-Williamson Tract by breaching the Mokelumne River levee and degrading the entire southwest levee. Objective - promote natural flooding processes and restoring seasonal floodplain in order to enhance rearing habitat for juvenile Chinook salmon)			
Admin	Funding source(s) and budgets for project planning, implementation, and monitoring are in place.	Necessary funding is secured and detailed budget developed by [Date].	Percent of required funding secured.
Admin	Environmental compliance documents are completed and regulatory permits obtained.	Environmental compliance documents (e.g., EIR) are certified by [Date]. Regulatory permits are issued by [Date].	Certification of environmental compliance documents and issuance of regulatory permits.
Driver	Interannual frequency, timing, duration, and magnitude of floodplain inundation sufficient to support the restoration and maintenance of functional floodplain habitat.	Interannual frequency - annual flood events (1-3 per year or more in wet years) (Winternitz 2011). Timing and duration - provide early season flooding from early January through April. Flooding can come in pulses, but continuous inundation of at least some areas is important (Moyle et al. 2007). Specific targets to be developed. Magnitude – floodplain area is expected to be 400 acres (Winternitz 2011).	Inundation regime (return rate, timing, duration, magnitude).
Driver	Use of restored floodplain as rearing habitat by juvenile salmonids.	Juvenile salmonids will be present within restored floodplains for sufficient period to signify use as rearing habitat as opposed to migration corridor. Specific target to be developed.	Species and density, residence time within restored habitats.
Driver	Chlorophyll concentrations (indicator of phytoplankton primary productivity).	Chlorophyll concentrations exceed 10 µg L^{-1} (Müller-Solger et al. 2002) during drain cycle.	Chlorophyll a concentration.
Driver	Zooplankton and macroinvertebrate density.	Targets to be developed.	Species and density.
Outcome	Enhanced growth rates of juvenile salmonids rearing on the floodplain.	Target to be developed, based on work of Jeffres et al. (2008), Sommer et al. (2001b, 2005), and other appropriate studies.	Growth rate.

Type	Performance Measure	Target	Metric
Program-Level (Programmatic evaluation of ERP's efforts relevant to floodplain restoration/protection, including the McCormack-Williamson Tract action described above and other relevant actions)			
Admin	ERP in collaboration with the Delta Conservancy, stakeholder groups, DWR, DSC/DSP, Federal agencies, and other appropriate entities develop and adopt a clear strategy (including prioritization) and spatial and temporal targets for restoration of floodplain habitat in the Delta by [Date] (derived from DSC 2012).	Clear strategies and spatial and temporal targets for restoration of floodplain habitat in the Delta are adopted by [Date].	Percent completion of strategies.
Driver	Number of floodplain restoration projects developed and implemented in the Delta.	Targets to be developed based on the strategy identified above.	Number of projects (+ total acreage), percentage of projects identified in the strategy (see administrative measure) that have been successfully implemented.
Outcome	Amount of floodplain habitat protected, restored or enhanced in the Cosumnes-Mokelumne Confluence.	Targets to be determined through effort to develop and adopt a clear strategy and spatial and temporal targets for restoration of floodplain habitat in the Delta.	Acres, percentage of target acreage identified in the strategy (see administrative measure).
Outcome	Progress toward the documented use of protected and restored habitats and migratory corridors by native resident and migratory Delta species (DSC 2012).	Trends in occurrence, use, and performance of native species in protected and restored habitats and corridors will be upward over the next decade (DSC 2012).	To be determined, potentially multiple metrics including presence/absence, growth, residence time, etc.

Type	Performance Measure	Target	Metric
System-Level (Evaluate outcomes associated with actions implemented by multiple programs and natural processes [e.g., the McCormack-Williamson Tract action is one of many actions that may contribute to these outcomes])			
Outcome	Annual estimate of number juvenile salmonids emigrating at Chipps Island.	Specific targets based on race and origin to be developed (linked to target for through-Delta survival).	Abundance estimate – by race and origin (Chipps Island Trawl survey).
Outcome	Annual estimate of through Delta survival rate of Mokelumne River watershed juvenile salmonids.	Through-Delta survival rate of juveniles ≥50% (EWG 2008).	Survival estimate.
Outcome	Progress toward achieving the State and Federal "doubling goal" for wild Central Valley salmonids (DSC 2012).	Natural production at levels not less than twice the average levels attained during the period of 1967-1991.	Estimate of natural production (sum of ocean and freshwater catches and freshwater spawning escapement that are attributed to natural spawning of that population in previous years).

III. Monitoring Program

The development of a monitoring program requires a process whereby decisions are made as to what to measure; how, where, and when to take measurements; and how to analyze and interpret the resulting data (National Research Council 1990). The widely varied scale of actions likely to be implemented during Stage 2 will require an extensive and thoughtfully designed monitoring program that will most likely rely in part on information generated by existing programs (e.g., USGS Delta Flows Network, Environmental Monitoring Program, Municipal Water Quality Investigation [MWQI] program, Fall Midwater Trawl, CAMP, etc.), and other programs currently in development, in combination with monitoring activities associated with individual ERP restoration actions. There are several types of monitoring that may be conducted in association with implementation of the selected conservation priorities during Stage 2:

- Implementation (compliance) monitoring would be built into project-specific requirements and would focus on whether the action(s) is being implemented as planned (e.g., fulfillment of grant requirements).
- Effectiveness (performance) monitoring would identify whether project-specific actions are achieving their expected outcomes or targets.
- Mechanistic monitoring would demonstrate whether the mechanisms thought to link actions to desired outcomes are operating as predicted.
- System-level monitoring would be used to evaluate the degree of success of ERP and other related efforts relative to achieving program goals, objectives and conservation priorities as described in this Conservation Strategy and other foundational documents (Appendix E). This holistic approach requires a sustained, long-term commitment to monitoring of critical features of the entire system and a collaborative effort among multiple programs (Atkinson et al. 2004, Dahm et al. 2009).

Effective monitoring and assessment requires attention to several aspects of program design and implementation. Clearly articulated assessment questions are an essential prerequisite for effective monitoring. While monitoring designs that address specific questions may differ depending on their scale and/or site specific circumstances, such site-specific designs can often use standardized core indicators and standardized sampling, quality assurance and data management methods, allowing for the production of comparable data that can be more readily integrated with data from other programs/projects and used for assessments at different scales (Bonar and Hubert 2002, Brown 2003, Bernstein 2010). For example, data collected through effectiveness monitoring conducted at the project-level by ERP could potentially be integrated with data collected by other programs, provided monitoring designs are comparable, to address questions at broader scales (e.g., system-level assessments).

An environmental indicator is a measurable feature or group of features that provide managerially and scientifically useful evidence of environmental and ecosystem quality or reliable evidence of trends in quality (Intergovernmental Task Force on Monitoring Water Quality 1995). Indicators are useful to track the performance of management actions (refer to Section II - Performance Measures). The criteria for selecting indicators are based on scientific, practical, and programmatic considerations. For example, indicators must not only be scientifically valid and able to address the questions posed by the monitoring program, but their application must be practical when placed within the constraints of the monitoring program.

Many of the conservation priorities identified in this Conservation Strategy are anticipated to lead to changes in environmental conditions over time. However, being able to demonstrate those changes have occurred requires the collection of data both prior to and following implementation of the action. Data collected prior to implementation are used to establish baseline conditions for evaluating changes that result from the action. An extensive set of baseline data is available because of the efforts of the IEP and others. Where feasible, the establishment and maintenance of a network of reference sites (e.g., the Reference Condition Management Program implemented by the Surface Water Ambient Monitoring Program [SWAMP]) is another important consideration. Reference conditions (based on reference sites) provide a mechanism for defining appropriate expectations and accounting for natural variability. Reference sites represent the desired state of condition for a region of interest and set the biological condition benchmarks (expectations) for comparisons to the site(s) being evaluated (Ode and Schiff 2009). Furthermore, understanding reference conditions creates a solid foundation for setting performance measures that are relevant in the context of climate change and sea-level rise. Reference condition may also be determined based on previously collected data that are representative of the desired conditions prior to a particular alteration (e.g., prior to channelization of a waterway).

There are several efforts underway to develop tools and frameworks that support better coordinated monitoring activities in the Delta and upstream watersheds. Efforts to enhance integration and comparability among existing and potential future monitoring and assessment programs are critical given the magnitude of the issues being addressed, the diverse array of entities involved, and resource (e.g., staffing, financial) constraints. Of key importance is improving our ability to integrate data from multiple studies to develop valid information for decision making. Examples of a few representative efforts are included below. ERP staff will continue to participate in or monitor the development and implementation of these frameworks and will seek opportunities to integrate ERP-related monitoring activities into them, as appropriate.

- A Delta Science Plan will be developed by the Delta Science Program, in collaboration with others (e.g., IEP), by December 31, 2013 (DSC 2012). The goal of the Delta Science Plan is to organize Delta science activities in an efficient, collaborative, and integrative manner. To ensure that the best available science is used to develop the Delta Science Plan, the Delta Independent Science Board will be asked to review the draft Delta Science Plan.

- Unified Monitoring, Assessment and Reporting Program (UMARP, Luoma et al. 2011) represents an on-going effort to develop a coordinated monitoring framework designed to support and unify data from multiple monitoring programs, provide a common focus across programs, and provide regular assessments of how the system is changing in response to changes in infrastructure and water management actions, ecosystem restoration activities, exogenous factors such as climate change, and human activities such as population growth and changes in land use.

- The Interagency Ecological Program (IEP) – The IEP is part of the monitoring networks in the Delta that provide continuous monitoring focused on real-time data of flow and general water quality characteristics such as salinity, temperature, and dissolved oxygen, with more limited coverage on a few other parameters such as chlorophyll florescence, organic carbon and nutrients. The IEP Environmental Monitoring Program (IEP EMP) is the most comprehensive "regional" monitoring program in the Delta and is ultimately driven by water right permit-related monitoring requirements. It conducts discrete monitoring of general water quality, nutrients, phytoplankton, zooplankton, and benthos at 14 sites representing main in- and ouflows of the Delta.

- California Water Quality Monitoring Council (CWQMC) - Under the overarching guidance of the CWQMC, theme-specific workgroups (e.g., California Estuary Monitoring Workgroup) evaluate relevant existing monitoring, assessment, and reporting efforts and work to enhance those efforts so as to improve the delivery of water quality and ecosystem health information to the user, in the form of theme-based internet portals. There are currently three workgroups associated with aquatic ecosystem health that are particularly relevant to ERP's activities. These are the California Estuaries Monitoring Workgroup, California Wetland Monitoring Workgroup, and Healthy Streams Workgroup.

- Central Valley Chinook Salmon In-River Escapement Monitoring Plan (Bergman et al. 2012) – This is a science-based collaborative approach to improve monitoring of adult Chinook salmon returning from the ocean to spawn in Central Valley streams (escapement) and harvested in freshwater. Accurate estimates of escapement are critical to sound management of ocean and inland harvest and monitoring the recovery of listed stocks. Sampling designs were reviewed and recommendations were made for improvement of the field and analytical methods used in the existing programs. The most appropriate survey/monitoring technique (i.e., mark-recapture carcass surveys, redd surveys, snorkel surveys, and fish device counters) was identified for each watershed. To improve data management and reporting, an online database was reorganized and updated to provide a centralized location for sharing Central Valley Chinook salmon escapement estimates and annual monitoring reports.

- A Comprehensive Monitoring Plan for Steelhead in the California Central Valley (Eilers et al. 2010) – The goal of this monitoring plan is to provide the data necessary to assess the restoration and recovery of steelhead populations by determining the distribution, abundance, and population trends if California Central Valley steelhead. The objectives of the plan include: estimate steelhead population abundance with levels of precision; examine trends in steelhead abundance; and identify the current spatial distribution and assess changes. The plan includes recommendations for the development of a centralized database and a coordinated reporting system to be utilized by all Central Valley steelhead monitoring programs.

- Wetland and Riparian Area Monitoring Program (WRAMP, CWMW 2010) – The WRAMP consists of coordinated, comparable regional and statewide efforts that use standardized methods to monitor and assess the effects of natural processes, climate change, government policies, and management actions on the distribution, abundance, and condition of wetlands and riparian areas at a variety of spatial scales (e.g., watershed, statewide). The standardized methods will include definitions for wetlands and riparian areas, a statewide classification system, mapping and delineation protocols, condition assessment protocols, data transfer protocols and data quality control procedures, and analytical and reporting methods. The program is modeled after the USEPA's Level 1-2-3 framework for monitoring and assessment of wetland resources. The fundamental elements of this framework are:
    - Level 1 consists of wetland and riparian inventories and answers questions about wetland extent and distribution.
    - Level 2 consists of rapid assessment, which uses cost-effective field-based diagnostic tools to assess the condition of wetland and riparian areas. Level 2 assessments answer questions about general wetland health.
    - Level 3 consists of intensive assessment to provide data to validate rapid methods, characterize reference condition, and diagnose the causes of wetland condition observed in Levels 1 and 2. Level 3 assessments can also be used to test hypotheses and provide insight into functions and processes.

- Delta Regional Monitoring Program (RMP) – The Central Valley Regional Water Quality Control Board has initiated an effort to develop a comprehensive monitoring and assessment program for contaminants in the Delta. The proposed goal of the Delta RMP is to collect, coordinate, integrate, and synthesize data and communicate information about water quality in the Delta to support management decisions. The program is intended to address several needs that are presently unmet, including filling existing data gaps on contaminants, comprehensive assessment and regular reporting, comprehensive assessment to support performance measures, and coordinated monitoring (Jabusch and Bernstein 2010).

- Comprehensive Assessment and Monitoring Program -- CAMP assesses progress toward the AFRP fish doubling goals, stated in section 3406 (b)(1) of the CVPIA, by monitoring natural production of adult anadromous fish in the Central Valley and comparing these data to AFRP production targets. CAMP activities focus on nine anadromous fish taxa: Chinook salmon (fall-, late fall-, winter-, and spring-run), steelhead, striped bass, American shad, white sturgeon, and green sturgeon. CAMP primarily relies on other entities (e.g., CDFW) to collect the information it analyzes and synthesizes. To the extent that funding is available, the program works with partners to provide partial funding to complete high-priority monitoring projects.

Constraints Associated with Implementing Grant Funded Monitoring Programs

The State of California has invested millions of dollars in water quality and ecosystem improvement projects; however, for a number of reasons, most of these projects do not generate monitoring data sufficient to determine whether the desired outcomes have been achieved (CWQMC 2010). This problem is not unique to ERP or California; for example, following a review of over 37,000 river rehabilitation projects in the U.S.A, Bernhardt et al. (2005) reported that only 10 percent of project records indicated that any form of monitoring or assessment occurred. A number of issues have been identified during implementation of Stage 1 of the ERP and other state-funded water quality and ecosystem improvement projects that limit our abilities to evaluate the outcomes of our actions. These include short limits on contract terms (three years); delays in executing contracts; necessary follow-up grants were often not received in a timely manner, if at all; lack of coordinated effort among individual grantee monitoring efforts; and lack of appropriate level of standardization associated with sampling, quality assurance, and data storage to ensure data comparability (Kleinschmidt / Jones & Stokes 2003; Scientific Planning and Review Committee [SPARC] 2006; CWQMC 2008, 2010; Natural Water Quality Committee 2010). In its Comprehensive Monitoring Program Strategy for California, the CWQMC (2010) noted contract reform is needed to improve the effectiveness and efficiency of California's monitoring and assessment programs.

The disconnect between the duration of grant agreements (generally 3 years) and the time necessary to evaluate outcomes of restoration activities and potentially other conservation priorities outlined in the Conservation Strategy is an important issue that remains to be resolved. The outcomes of many of these activities are not fully realized in the near term or until they are combined with other activities. Restoration activities, in particular, are long-term investments, that require sustained, reliable funding in order to sufficiently evaluate.

SECTION 5: ERP Goals and Conservation Priorities

Utilizing the goals, objectives, visions, targets, actions and measures outlined in the ERPP and MSCS documents, the ERP Strategic Plan for Ecosystem Restoration and conservation action concepts in this strategy, ERP identifies the following conservation priorities to help guide restoration activities during Stage 2. These conservation priorities build on the existing ERP Strategic Plan objectives and together provide an updated list of conservation priorities moving forward in Stage 2. These conservation priorities will serve as a guide to help identity the types and locations of potential restoration actions. The ERP Implementing Agencies may utilize additional conservation priorities that are not included in the list below to identify priority restoration activities as new needs arise and new scientific information becomes available. Additional priorities may come from existing and similar future programs and plans as found in Appendix B.

ERP is guided by six strategic goals that provide the basis for a vision of a desired future condition of the Focus Area. The conservation priorities for each goal are listed below. Studies, research and monitoring efforts necessary to refine, implement and adaptively manage actions associated with these conservation priorities are assumed to occur.

GOAL 1. RECOVER ENDANGERED AND OTHER AT-RISK SPECIES AND NATIVE BIOTIC COMMUNITIES: Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species. Support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

> CONSERVATION PRIORITY 1: Achieve recovery of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh.
>
> CONSERVATION PRIORITY 2: Contribute to the recovery of other at-risk native species.
>
> CONSERVATION PRIORITY 3: Enhance and/or conserve native biotic communities and their abundance and distribution.
>
> CONSERVATION PRIORITY 4: Maintain and enhance the abundance and distribution of native species.
>
> CONSERVATION PRIORITY 5: Establish and maintain operations at water diversions that minimize entrainment of at-risk fish species.
>
> CONSERVATION PRIORITY 6: Remove physical barriers that impede access for at-risk fish and wildlife species.

CONSERVATION PRIORITY 7: Study the effectiveness of physical and nonphysical barriers in controlling fish movements.

CONSERVATION PRIORITY 8: Screen unscreened diversions to protect all life stages of at-risk fish species.

CONSERVATION PRIORITY 9: Improve hatchery management to address adverse impacts to at-risk fish populations.

CONSERVATION PRIORITY 10: Minimize the impact of harvest management on at-risk native species.

GOAL 2. REHABILITATE ECOLOGICAL PROCESSES: Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing[1] human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

CONSERVATION PRIORITY 1: Establish and maintain hydrologic and hydrodynamic regimes that support the recovery and restoration of native species and biotic communities, and support the restoration and maintenance of functional natural habitats.

CONSERVATION PRIORITY 2: Increase productivity and rehabilitate appropriate food web processes to support the recovery and restoration of native species and biotic communities.

CONSERVATION PRIORITY 3: Rehabilitate natural processes to create and maintain appropriate, connected aquatic and terrestrial habitats of suitable quantity and quality.

CONSERVATION PRIORITY 4: Create and maintain hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species, and biotic communities.

CONSERVATION PRIORITY 5: Create and/or maintain temperature regimes in rivers that support the recovery and restoration of native aquatic species.

CONSERVATION PRIORITY 6: Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats, including freely meandering reaches.

1. "Minimal ongoing human intervention" is not intended to limit existing restoration effort. It seeks to focus on future restoration so that its values are maintained with minimal additional effort.

CONSERVATION PRIORITY 7: Balance sediment supplies so that coarse sediment below reservoirs provides sufficient spawning habitat where fine sediment does not cause adverse ecological effects and sufficient sediment is provided downstream to help provide adequate turbidity for pelagic fishes in the Delta.

GOAL 3. ENHANCE/MAINTAIN HARVESTED SPECIES: Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

CONSERVATION PRIORITY 1: Enhance, to the extent consistent with ERP goals, populations of fish, waterfowl and upland game for harvest by hunting and for non-consumptive recreation.

GOAL 4. PROTECT, RESTORE, AND/OR ENHANCE HABITATS: Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

CONSERVATION PRIORITY 1: Restore and enhance large expanses of all major habitat types, providing sufficient connectivity to support recovery and restoration of native species and biotic communities, and rehabilitation of ecological processes.

CONSERVATION PRIORITY 2: Protect tracts of existing aquatic, wetland, and upland habitat types, providing sufficient connectivity to support recovery and restoration of native species and biotic communities, rehabilitation of ecological processes, and public value functions.

CONSERVATION PRIORITY 3: Minimize the conversion of agricultural land to urban and suburban uses, maintain open space buffers in areas adjacent to existing and future restored habitats, and manage agricultural lands in ways that are favorable to wildlife.

CONSERVATION PRIORITY 4: Manage floodplain habitats to enhance seasonal shallow water benefits for native fish and wildlife, including the Yolo and Sutter bypasses.

GOAL 5. PREVENT/CONTROL NON-NATIVE INVASIVE SPECIES: Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.

CONSERVATION PRIORITY 1: Improve coordination and collaboration among local, state, federal, and non-governmental agencies and entities regarding NIS prevention and control activities.

CONSERVATION PRIORITY 2: Develop, implement, manage, and maintain long-term programs to minimize and prevent the introduction and spread of NIS into and throughout the Focus Area.

CONSERVATION PRIORITY 3: Develop, implement, manage, and maintain long-term programs to monitor the early detection of new NIS as well as existing NIS.

CONSERVATION PRIORITY 4: Develop, implement, manage, and maintain long-term programs for rapid response, control, and eradication of NIS.

CONSERVATION PRIORITY 5: Develop, implement, manage, and maintain long-term programs to measure the effects and minimize the long-term impacts of NIS on native species and their habitats, including reduction of non-native predation.

CONSERVATION PRIORITY 6: Develop, implement, manage, and maintain long-term programs to provide education and outreach regarding NIS to the general public as well as public and private agencies and entities to ensure awareness of NIS threats and management priorities.

CONSERVATION PRIORITY 7: Develop, implement, manage, and maintain long-term research programs to obtain a better understanding of the biology of NIS; the ecological and economic impacts of NIS invasions; and control, treatment, and eradication options to improve long-term management of NIS.

CONSERVATION PRIORITY 8: Review state laws and regulations to ensure they promote the long-term prevention and management of NIS introductions.

GOAL 6. IMPROVE/MAINTAIN WATER AND SEDIMENT QUALITY: Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

CONSERVATION PRIORITY 1: Reduce the loadings and concentrations of toxic contaminants in the environment to levels that do not adversely affect organisms, wildlife, and human health.

CONSERVATION PRIORITY 2: Reduce loadings of oxygen-depleting substances from human activities into aquatic ecosystems to levels that do not cause adverse ecological effects.

CONSERVATION PRIORITY 3: Improve coordination with the Water Boards, IEP and other entities on evaluating ecological effects from water and sediment quality stressors and methods to reduce these stressors.

CONSERVATION PRIORITY 4: Work with the Water Boards and other entities to participate in a long-term integrated monitoring program that evaluates water and sediment quality stressors and ecological impacts to wildlife.

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Appendix A – Acronyms and Abbreviations

ACID	Anderson-Cottonwood Irrigation District
AFRP	Anadromous Fish Restoration Program
AFSP	Anadromous Fish Screen Program
AMPT	Adaptive Management Planning Team
ASIP	Action-Specific Implementation Plan
Bay-Delta	San Francisco Bay/Sacramento-San Joaquin Delta Estuary (including Suisun Marsh)
BDCP	Bay-Delta Conservation Plan
BMPs	Best Management Practices
BO	Biological Opinion
BOD	Biological Oxygen Demand
CAISMP	California Aquatic Invasive Species Management Plan
CDBW	California Department of Boating and Waterways
CDFW	California Department of Fish and Wildlife
CEHCP	California Essential Habitat Connectivity Project
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
cfs	cubic feet per second
Conservancy	Sacramento-San Joaquin Delta Conservancy
CSLC	California State Lands Commission
CVJV	Central Valley Joint Venture
CVP	Central Valley Project
CVPIA	Central Valley Project Improvement Act
CVRWQCB	Central Valley Regional Water Quality Control Board
CVSSRP	Central Valley Salmon and Steelhead Recovery Plan
CWQMC	California Water Quality Monitoring Council
D-1641	State Water Resources Control Board Decision 1641
DCC	Delta Cross Channel
DDT	Dichlor-diphenyl-trichlorethylene
DES	Diethylstribestrol
DFG	California Department of Fish and Game
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
DPR	Department of Pesticide Regulations
DRERIP	Delta Regional Ecosystem Restoration Implementation Plan
DRMS	Delta Risk Management Strategy
DSC	Delta Stewardship Council
DSWG	Delta Smelt Working Group
DVC	Delta Vision Committee
DWR	California Department of Water Resources
DWSC	Deep Water Ship Channel
E/I	Export/Inflow ratio
EDCs	Endocrine disruptive Chemicals
EFH	Essential Fish Habitat

EIS/EIR	Environmental Impact Statement/Environmental Impact Report
EMU	Ecological Management Unit
EMZ	Ecological Management Zone
ERP	Ecosystem Restoration Program
ERPiams	Ecosystem Restoration Program Implementing Agencies
ERPP	Ecosystem Restoration Program Plan
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
EWA	Environmental Water Account
EWG	Ecosystem Work Group
FPIP	Fish Passage Improvement Program
HACCP	Hazard Analysis and Critical Control Points planning
IEP	Interagency Ecological Program
IFIM	USFWS Instream Flow Incremental Methodology
μmol/L	micromoles per liter
Legal Delta	Sacramento-San Joaquin Delta as defined in Water Code section 12220)
MSCS	Multi-Species Conservation Strategy
MWQI	Municipal Water Quality Investigations
NCCP	Natural Community Conservation Plan
NCCPA	Natural Community Conservation Planning Act
NECS	Natural Resource Conservation Service
NEPA	National Environmental Policy Act
NIS	Non-native Invasive Species
NISP	Non-native Invasive Species Program
NISAC	Non-native Invasive Species Advisory Council
NMFS	National Marine Fisheries Service
NOAA Fisheries	National Marine Fisheries Service
OCAP	Operations Criteria and Plan
OMR	Old and Middle Rivers
OP	Organophosphate (pesticides)
PBDEs	Polybrominated Diphenyl Ethers
PCBs	Polychlorinated Biphenyls
PMFC	Pacific Fisheries Marine Council
POD	Pelagic Organism Decline
PPIC	Public Policy Institute of California
PWA	Phillip Williams Associates
RBDD	Red Bluff Diversion Dam
RBPP	Red Bluff Pumping Plant
Reclamation	Bureau of Reclamation
ROD	Record of Decision
RPA	Reasonable and Prudent Alternative
RWQCB	Regional Water Quality Control Board
SacEFT	Sacramento River Ecological Flows Tool
SAV	Submerged Aquatic Vegetation
SBDS	State of Bay-Delta Science Report

SHA	Safe Harbor Agreement
SJRRP	San Joaquin River Restoration Program
SJBPA	San Joaquin Basin Planning Area
SMSCS	Suisun Marsh Salinity Control Structure
SRA	Shaded Riverine Aquatic Habitat
SWAMP	Surface Water Ambient Monitoring Program
SWP	State Water Project
SWR	Sacramento Wildlife Refuge
SWRCB	State Water Resources Control Board
Task Force	Delta Vision Blue Ribbon Task Force
TBT	Tributiltin
TCCA	Tehama Colusa Canal Authority
TIE	Toxicity Identification Evaluation
TMDL	Total Maximum Daily Load
TRT	NOAA Fisheries Technical Recovery Team
UMARP	Unified Monitoring, Assessment and Reporting Program
USEPA	U.S. Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VAMP	Vernalis Adaptive Management Program
VELB	Valley Elderberry Longhorn Beetle
WARMF	Watershed Analysis Risk Management Framework
X2	The horizontal distance in kilometers up the axis of the estuary from the Golden Gate Bridge to where the tidally averaged near-bottom salinity is 2 practical salinity units (psu)

Appendix B – Other Efforts Related to the Conservation Strategy

Efforts for the Sacramento-San Joaquin Delta and the Sacramento and San Joaquin Valley Regions are just as complex and dynamic as the physical system itself. This Conservation Strategy was written recognizing that these efforts must be complementary and integrated to successfully achieve desired outcomes for a sustainable ecosystem.

Several concurrent efforts are evaluating the status of the Delta, Sacramento Valley Region, and the San Joaquin Valley Region resources, future use of those resources, and the risk to those resources from controllable and uncontrollable drivers of change. The Conservation Strategy both informs and was informed by these efforts, and information exchange will continue as respective efforts are carried out. Below is a brief description of the numerous efforts that are relevant to all of the regions that have been important to the development of this Conservation Strategy. The ERP Implementing Agencies anticipate that this Conservation Strategy will provide an important portion of the biological foundation for these other efforts.

Bay-Delta Conservation Plan (BDCP). The BDCP is an applicant-driven process through which covered activities are permitted under the ESA and the Natural Community Conservation Planning Act (NCCPA) in the context of an overall conservation plan for the Plan Area. The BDCP is being prepared through a collaboration of state, federal, and local water agencies, state and federal wildlife agencies, environmental organizations, and other interested parties with the goal of protecting and restoring the ecological health of California's Sacramento-San Joaquin River Delta and providing a more reliable water supply. The intent is to develop a joint Natural Community Conservation Plan and Habitat Conservation Plan.

The BDCP Steering Committee members signed a Planning Agreement in 2006, in accordance with the NCCPA, that identified the planning area, covered activities, covered species, and natural communities that would be included in the conservation plan. In the first half of 2007, the Steering Committee identified a number of stressors affecting the aquatic species listed in the Planning Agreement and developed four conceptual options for water conveyance through or around the Delta to address those stressors. In late 2007, an initial evaluation of the four conveyance options was completed. Based on that evaluation, the Steering Committee agreed that the Dual Conveyance Option provided the best opportunity to meet the objectives of the Planning Agreement. Modeling to evaluate conveyance operations of the options and conservation actions was conducted beginning in 2008. National Environmental Protection Act (NEPA) and California Environmental Quality Act (CEQA) environmental documentation began in early 2009, and working drafts of portions of the BDCP are currently being released for public review (See: http://baydeltaconservationplan.com/Home.aspx).

The Delta Reform Act imposed requirements on DWR as it prepares the BDCP. The BDCP would only be permitted to be incorporated into the Delta Plan if certain requirements are met. CDFW will be a permitting agency in the BDCP under the Natural Community Conservation Planning Act (NCCPA). To assure that the BDCP conforms to the requirements of the NCCPA, CDFW is actively involved in providing policy, technical guidance, and support to that planning effort. ERP agencies are working with BDCP applicant staff to help ensure that it meets associated NCCPA and HCP species recovery, habitat enhancement, monitoring and minimization and mitigation requirements.

CALFED Watershed Program. This program shares many goals and objectives with ERP, and millions of dollars of Watershed Program funds were allocated to projects in the Sacramento Valley Region. These include watershed assessments, watershed management plans, restoration projects, and the funding of watershed coordinators.

California Wildlife Action Plan. CDFW, in partnership with U.C. Davis's Wildlife Health Center, developed the California Wildlife Action Plan to identify the State's species and habitats that are of greatest conservation need, the major stressors affecting native wildlife and habitats, and actions needed to restore and conserve wildlife to reduce the likelihood of more species becoming threatened or endangered (Atkinson et al. 2004). The information provides guidance on implementing adaptive management for conservation plans that address multiple species. The Action Plan is currently being revised to address implications resulting from climate change and other significant uncertainties. (See: http://www.dfg.ca.gov/SWAP/)

The California Water Quality Monitoring Council (CWQMC). The CWQMC was formed as a result of an MOU signed by the Secretaries of the California Natural Resources Agency and the California Environmental Protection Agency (Cal/EPA), as mandated by the Senate Bill 1070. The MOU and Senate Bill 1070 (Water Code Sections 13167 and 13181) require that the CWQMC develop specific recommendations to improve the coordination and cost-effectiveness of water quality and ecosystem monitoring and assessment, enhance integration of monitoring data across departments and agencies, and increase public accessibility to monitoring data and assessment information. A key recommendation of the CWQMC is to provide a platform for intuitive, streamlined access to water quality and ecosystem information that directly addresses users' questions and decision-making needs. To implement its vision, the CWQMC and its theme-specific workgroups are developing the "My Water Quality" website (www.CaWaterQuality.net) to provide a single, global access point to a set of theme-based internet portals. The website is designed around clear intuitive questions that are readily understood by decision makers, agency managers, legislators, scientists, and the public (e.g., Are our aquatic ecosystems healthy?). The internet portals and associated workgroups pertaining to ecosystem health within rivers/streams, estuaries, and wetlands are of particular relevance to the ERP.

Central Valley Flood Management Planning (CVFMP). DWR's CVFMP is designed to improve integrated flood management in the Sacramento and San Joaquin Valleys. Legislation passed in 2007 directs the DWR to develop three important documents that will guide improvement of integrated flood management: 1) State Plan of Flood Control

(SPFC) Descriptive Document that will inventory and describe the flood management facilities, land, programs, conditions, and mode of operations and maintenance for the State and Federal flood protection system in the Central Valley, 2) Flood Control System Status Report that will assess the status of the facilities included in the SPFC Descriptive Document, identify deficiencies, and make recommendations, and 3) Central Valley Flood Protection Plan (CVFPP) that will describe a sustainable, integrated flood management plan that reflects a system-wide approach for protecting areas of the Central Valley currently receiving protection from flooding by existing facilities of the SPFC. Primary authorization for the CVFPP originates in the Central Valley Flood Protection Act of 2008. (See: http://www.water.ca.gov/cvfmp/)

The DWR is required to prepare the CVFPP by January 1, 2012, for adoption by the Central Valley Flood Protection Board by July 1, 2012, and to update the plan every five years (years ending in “2” and “7”). Completion of the SPFC Descriptive Document and the Flood Control System Status Report will contribute to development of the CVFPP along with existing information and new data developed by other FloodSAFE programs and projects, including the Central Valley Floodplain Evaluation and Delineation Program, Delta Risk Management Strategy, Central Valley Flood Planning Hydrology Update, California Levee Database, and Levee Evaluation Program.

Central Valley Integrated Flood Management Study. The USACE is initiating the Central Valley Integrated Flood Management Study (CVIFMS), a watershed study with DWR as the nonfederal sponsor. With this study, the USACE will define a long-range flood management program for the Sacramento River and San Joaquin River basins and the corresponding level of federal participation. It will identify opportunities to reduce flood risk by improving the flood capacity of the system while restoring and protecting floodplain and environmental features, including wetlands and other fish and wildlife habitat. This effort will build on the Sacramento River and San Joaquin River basins Comprehensive Study (concluded in 2001). USACE intends to coordinate their effort with DWR’s work on the CVFPP so that joint products can be produced for mutual benefits and use. They also intend to coordinate with other ongoing projects and programs to incorporate relevant information and actions in study development. The USACE plans to complete the CVIFMS by 2015. (See: http://www.water.ca.gov/cvfmp)

Central Valley Joint Venture (CVJV) 2006 Implementation Plan. The Central Valley Joint Venture (CVJV) was formed to protect, restore, and enhance wetlands and associated habitats for waterfowl, shorebirds, waterbirds, and riparian songbirds through partnerships with conservation organizations, public agencies, private landowners, and others interested in Central Valley bird habitat conservation. The CVJV 2006 Implementation Plan incorporates new information and broadens the scope of conservation activities to include objectives for breeding waterfowl, breeding and non-breeding shorebirds, waterbirds, and riparian-dependent songbirds. It lists specific goals and objectives for these species, and considers both biological and non-biological factors in establishing bird-group conservation objectives. The CVJV 2006 Implementation Plan also contains Central Valley-wide objectives for protecting, restoring, or enhancing seasonal and semi-permanent wetlands, riparian areas, rice cropland, and waterfowl-friendly agricultural crops (CVJV 2006).

Ducks Unlimited, one of the partners in the CVJV, has completed 46 wetland restoration and protection projects benefiting migratory birds and other wildlife on approximately 20,000 acres in the Delta. ERP Implementing Agencies anticipate that these efforts to benefit waterfowl and other avian and terrestrial species will continue to enhance ecosystem function and survival of those species. Restoration actions of this type are identified in the CVJV 2006 Implementation Plan and are consistent with the Conservation Strategy. (See: http://www.centralvalleyjointventure.org/science)

Central Valley Project Improvement Act (CVPIA) Programs. The Central Valley Project Improvement Act (CVPIA), signed into law in 1992, mandates changes in management of the CVP, particularly for the protection, restoration, and enhancement of fish and wildlife. Over the past 20 years, CVPIA Programs have made significant improvements to wildlife and fish by restoring habitat and enhancing fish passage and survival. The enormity and complexity of the Central Valley ecosystem requires a comprehensive approach with participation at all levels.

The last program-wide plan for the CVPIA was completed in 1998 and was intended to guide planning efforts through at least 2003. A CVPIA Fisheries Revisioning effort is currently underway that will articulate a process for collaborating with stakeholders and other agencies, as well as bring forward a plan to update and refine implementation of the CVPIA for the next 10-year period. This 10 year implementation plan will detail the accomplishments and limitations of the CVPIA to date and will articulate the goals, priorities, and actions to be implemented over the next ten years. The implementation plan is a continuation and refinement of other earlier planning efforts, and does not reflect a major redirection of the Program.

Previous planning documents have addressed activities undertaken under the authority of CVPIA by linking them to specific provisions of the Act. This structure provided a clear linkage between activities and the Act, but did not always support the integrated nature of the CVPIA Program and of Central Valley water distribution and restoration efforts. The new plan refines the organization of the CVPIA restoration provisions by grouping them into three resource areas: fisheries, refuge water supply, and other resources. A fourth category, program management activities that support the CVPIA Program, was also created. This method of organization was developed by the program managers to allow for better coordination across provisions. Improved planning and coordination is seen as critical to the success of the long-term goals of the CVPIA. Several of the existing CVPIA programs are explained below.

- ***Anadromous Fish Restoration Program (AFRP).*** Other CVPIA provisions contain elements that relate to the AFRP and the Federal fish doubling goal. (Section 3406(b)(1)) calls for the establishment of a program to ensure the natural production of anadromous fish in Central Valley Rivers and streams will be sustainable, on a long-term basis, at levels not less than twice the average levels attained during the period of 1967-1991. A program to provide spawning gravel and riparian habitat for anadromous fish (Section 3406(b) (13)) authorizes the implementation of gravel restoration projects on the upper Sacramento, American and Stanislaus rivers in the Central Valley. Section 3406 (b)(21) of the CVPIA directs Reclamation and the USFWS to assist the State of California in installing fish screens on major unscreened or inadequately screened water diversions that may be resulting in the loss of juvenile salmon and other fish species, thereby affecting overall production. Actions that are related specifically to the restoration of fisheries on Clear Creek are identified in Section 3406(b)(12) of the CVPIA.

- ***Refuge Water Supply Program****.* Most of the historical wetland areas in the Sacramento Valley have been converted to other land uses over the past 150 years. Less than five percent of the more than 4,000,000 original acres of seasonal and permanent wetlands now remain. These remnants in the Central Valley must be intensively managed to support waterfowl populations that depend on the Central Valley for wintering habitat. The CVPIA Refuge Water Supply Program (RWSP) is comprised of three components: water acquisition, conveyance, and facilities construction. The RWSP's goal is to ensure all CVPIA identified refuges (wetland habitat areas) annually receive water of a specified quantity, suitable flow rate, and suitable quality to support their wetland and aquatic environments.

  Section 3406(d)(1) of the CVPIA established the primary requirement goal of providing full Level 2 water supplies[2] of suitable quality to maintain and improve wetland habitat areas on 19 refuges, including National Wildlife Refuge Systems in the Sacramento and San Joaquin Valleys, Central Valley state wildlife management areas, and the Grasslands Resources Conservation District. In addition, section 3406(d)(2) required the Department of the Interior to provide incremental Level 4 refuge water supplies to Central Valley refuges using section 3406(b)(3) to acquire water as necessary.

  The associated increase in water supply and reliability has created new wetlands and enhanced existing wetlands, resulting in increases in populations of Federal and State listed species, particularly avian species, and other wildlife species such as the giant garter snake (*Thamnophis gigas*). Avian species that have benefited include the peregrine falcon (*Falco peregrinus*), southern bald eagle (*Haliaeetus leucocephalus washingtoniensis*), tri-colored blackbird (*Agelaius tricolor*) and white-faced ibis (*Plegadis chihi*). The better water supply and reliability for refuges has also reduced the concentration of salts and other contaminants, thereby improving the quality of water on the refuges, and the quality of water discharged from the refuges.

2. [2] As identified in the *"Dependable Water Supply Needs"* table for those habitat areas as set forth in the Refuge Water Supply Report and two thirds of the water supply needed for full habitat development for those habitat areas identified in the *"San Joaquin Basin Action Plan/Kesterson Mitigation Action Plan Report."*

- ***Habitat Restoration Program.*** The CVPIA Habitat Restoration Program (HRP) was developed under Section 3406 (b)(1) "Other" of the CVPIA to address the needs of native fish and wildlife affected by the CVP that were not specifically addressed in other portions of the CVPIA. The HRP focuses on protecting native habitats that have been directly affected by construction and operation activities of the CVP and that have also experienced or are experiencing the greatest decline in species that are federally listed, proposed, or candidate for listing under the ESA. Other considerations include state-listed species and non-listed state and federal species of special concern or other associated native wildlife species. To date, the HRP has funded nearly 90 new projects with a total budget of over $23 million dollars. Much of the focus of the HRP since 1992 has been on acquiring land either through fee title or conservation easement. More than 100,000 acres of habitat has been protected by efforts that include contributions from the HRP, including vernal pool, riparian, alkali scrub, foothill chaparral, valley-foothill hardwood, and grassland habitats. The HRP has also co-funded eight riparian restoration projects which have contributed to more than 1,000 restored acres. Additionally, more than 30 studies/surveys have been funded through these projects including captive breeding and reintroduction, distribution and status surveys, genetics studies, assessment of relocation efforts, and grazing impacts studies. The program has also supported pilot programs that contribute to the long-term scientific understanding of restoration actions.

The Delta Conservancy. The Delta Reform Act legislation created the Sacramento-San Joaquin Delta Conservancy to act as a primary state agency to implement ecosystem restoration in the Delta. The Conservancy is also directed to support efforts that advance environmental protection and the economic wellbeing of Delta residents. The Conservancy is governed by a 23-member Board, including 11 voting members, 2 non-voting members, and 10 liaison advisors. The Delta Conservancy Board is required by statute to complete and adopt a strategic plan by March 2013 (Delta Conservancy 2011).

Delta Vision Strategic Plan. The Delta Vision process began in 2006 after Executive Order S-17-06, which established the Delta Vision Committee (DVC), the Delta Vision Blue Ribbon Task Force (Task Force). The goal of the Delta Vision process was to "develop a durable vision for sustainable management of the Delta." The seven-member Task Force completed their strategic plan in 2008. In December 2008, recommendations on how to implement the Delta Vision Strategic Plan were submitted to the Governor and Legislature by the DVC.

The Delta Vision effort had a broader focus than the ERP, and a longer time frame (until 2100). The Task Force issued recommendations that addressed an array of natural resources, infrastructure, land use, and governance issues necessary to achieve a sustainable Delta. The Delta Vision effort began with the consensus that current uses and resources of the Sacramento-San Joaquin Delta estuary, including the Suisun Bay and Marsh, are unsustainable over the long-term. The process took into consideration changing climatic, hydrologic, environmental, seismic, and land use conditions that may jeopardize the Delta's natural and human infrastructure.

The Delta Task Force made twelve integrated and linked recommendations, notably "The Delta ecosystem and a reliable water supply for California are the co-equal goals for sustainable management of the Delta" (BRTF 2007). These co-equal goals became focal points for the Delta Vision Strategic Plan, which listed seven goals and strategies to achieving those goals (BRTF 2008). Goal 3 in their strategic plan is to restore the Delta ecosystem as the heart of a healthy estuary, and includes five strategies and twenty associated actions to achieve that goal.

In its Implementation Report (DVC 2008), the DVC noted several important actions required to carry out many of its recommended actions toward achieving the two co-equal goals. In addition to continued implementation of the ERP, these include: completion of the Bay-Delta Conservation Plan (BDCP); updating of Bay-Delta water quality standards; evaluation and initial construction of gates and barriers in the Delta; development and implementation of instream flow recommendations; control of aquatic invasive species; evaluation of other potential stressors to ecological processes, habitats, and species; and initiation of comprehensive monitoring of Delta water quality and fish and wildlife health. CDFW presented earlier drafts of the ERP Conservation Strategy to the DVC, who considered and included many of the Conservation Strategy's concepts in their own documents.

The Delta Vision effort led to the passage of the Delta Reform Act (SBX7-1) which created the Delta Stewardship Council who are mandated to develop, adopt, and implement by January 1, 2012, a legally enforceable, comprehensive, long-term management plan for the Sacramento-San Joaquin Delta and the Suisun Marsh—the Delta Plan—that achieves the coequal goals of "providing a more reliable water supply for California and protecting, restoring and enhancing the Delta ecosystem" and does this "in a manner that protects and enhances the unique cultural, recreational, natural resource and agricultural values of the Delta as an evolving place" (Water Code section 85054).

Delta Risk Management Strategy (DRMS). The CALFED ROD required the completion of a risk assessment that would evaluate sustainability of the Delta, as well as assess major risks to Delta resources and infrastructure from flooding, seepage, subsidence, and earthquakes. Assembly Bill 1200, chaptered in October 2005, requires that DWR evaluate the potential impacts on Delta resources and infrastructure, based on 50-, 100-, and 200-year projections, from subsidence, earthquakes, floods, climate change and sea level rise, or a combination of these factors. DWR and CDFW are then required to develop principal options for the Delta and evaluate and comparatively rate the options with regard to these variables. CDFW /DWR's report, which summarizes progress on evaluations of potential impacts, improvements, and options for fishery and water supply uses of the Delta, was submitted to the Legislature in early 2008 (URS 2008). (See: http://www.water.ca.gov/floodmgmt/dsmo/sab/drmsp/)

Delta Stewardship Council (Delta Plan). The Delta Stewardship Council (DSC) was also created by the Delta Reform Act to adopt and oversee implementation of a comprehensive management plan for the Delta by January 1, 2012. This plan will be used to guide state and local actions in the Delta in a manner that furthers the co-equal goals of ecosystem restoration and improved water supply reliability. The DSC is required to develop, adopt and commence implementation of a comprehensive resource management plan for the Delta (Delta Plan) to achieve the coequal goals. The goals are 1) providing a more reliable water supply; and 2) protecting, restoring and enhancing the Delta ecosystem. The Delta Plan also includes performance measurements that will enable the DSC to track progress in meeting the objectives of the Delta Plan. A state or local public agency that proposes to undertake certain proposed actions that will occur with the boundaries of the Delta or the Suisun Marsh is required to prepare and submit to the DSC written certification.

Environmental Quality Incentive Program (EQIP) and Wetland Reserve Program (WRP); managed by the National Resource Conservation Service (NRCS). EQIP incentive payments complement the objectives contained in the CALFED ERP while focusing on the role agricultural lands can play to provide habitat to fish and wildlife species. Approved projects optimize environmental benefits, while also addressing natural resource concerns, and are awarded based on criteria consistent with the goals of EQIP. Projects using WRP funding similarly complement the objectives contained in the CALFED ERP and the objectives of the WRP.

The WRP objectives are to purchase conservation easements from willing sellers; restore and protect wetlands in agricultural settings; remove environmentally sensitive, marginal cropland from cultivation; assist landowners with restoration of wetland hydrology; and contribute to the national goal of no net loss of wetlands. Approved projects optimize environmental benefits while addressing natural resource concerns and are awarded based on their state wide rank consistent with the goals of WRP.

Federal Biological Opinions. In response to the POD, court-mandated restrictions in the amount of water pumped by the SWP and CVP were implemented in late 2007, while the USFWS and NOAA Fisheries developed new Biological Opinions on the coordinated operations of the State and Federal water projects. The USFWS Biological Opinion for delta smelt was completed in December 2008, and the NOAA Fisheries Biological Opinion for salmonids and green sturgeon was completed in June 2009. In combination, these two Biological Opinions include Reasonable and Prudent Alternative (RPA) actions that restrict the amount of reverse flows (and thus the amount of water that can be exported by the projects) in Old and Middle rivers during certain times of the year, provide for new X2 requirements in fall, and require modified operation of Delta Cross Channel (DCC) gates in late fall and early winter. These Biological Opinions are now driving operations of the SWP and CVP, and provide the current regulatory baseline for export operations from the Delta. (See: http://swr.nmfs.noaa.gov/ocap.htm (NMFS 2009a), and www.fws.gov/sacramento/es/documents/SWP-CVP_OPs_BO_12-15_final_OCR.pdf (USFWS 2008)).

Fish and Wildlife Service (USFWS) Delta Native Fishes Recovery Plan. Significant new information regarding status, biology, and threats to Delta native species has emerged since USFWS originally released its recovery plan in 1996 (USFWS 1996). The plan is being revised as new information is collected and reviewed. The information is used to develop a strategy for the conservation and restoration of Sacramento-San Joaquin Delta native fishes. Species covered by this plan are delta smelt, longfin smelt, Sacramento splittail, and Sacramento perch. The goal of the Delta Native Fishes Recovery Plan is to establish self-sustaining populations of these species. To be effective, recovery planning must consider not only species or assemblages of species, but also habitat components, specifically, their structure, function, and change processes. Restoration actions may also include establishing genetic refugia for delta smelt. A draft of the revised recovery plan is expected to be released by USFWS, although the recovery plan adopted in 1996 is available online.
(See: ecos.fws.gov/docs/recovery_plan/961126.pdf)

FloodSAFE *California Central Valley Flood Protection Plan and the California Water Plan*. CDFW is striving to assure that the Central Valley Flood Protection Plan (CVFPP), including its accompanying Conservation Strategy, are consistent with the ERP Conservation Strategy. ERP provides the Department of Water Resources (DWR) with data support, document review, as well as policy and technical advice related to the development of both the CVFPP and the California Water Plan (CWP). The CVFPP is legislatively mandated by the Central Valley Flood Protection Act to plan the long-term improvement of the flood management system in California’s Central Valley. The CVFPP is required to describe how DWR and other partners, will protect, enhance, and improve the status and trends of ecosystem processes, habitats, and species associated with this flood management system. The first public draft of the CVFPP was released in December of 2011 and is due to be adopted by the California Central Valley Flood Protection Board by July 1, 2012. The CVFPP will be updated and adopted every 5 years after its initial adoption in 2012.

The CWP provides a framework for water managers, legislators, and the public to consider options and make decisions regarding California’s water future. The CWP is updated every five years (next update due in 2013) and presents basic data and information on California’s water resources including water supply evaluations and assessments of agricultural, urban, and environmental water uses to quantify the gap between water supplies and uses. The CWP also identifies and evaluates existing and proposed statewide demand management and water supply augmentation programs, and projects to address the State’s water needs.

Grassland Stewardship Plan. The Grassland Water District (GWD) is applying to the DWR CALFED Watershed Program for financial assistance to complete the first of a three phase comprehensive Grassland Stewardship Plan (GSP). The GSP focus area is in the Los Banos area of Merced County. The area is bisected by the San Joaquin River, a 303(d) listed waterway under the Federal Clean Water Act, which ultimately drains to the Sacramento-San Joaquin Delta. The focus area is highly complex including State and Federal wildlife refuges, lands protected by various conservation easements, and other private lands. The GSP has the following goals:

- Ensure a broad consensus-based process.
- Simplify compliance with regulatory requirements without compromising environmental protection.
- Balance the objectives of water supply management, habitat protection, flood management, and land use to protect and enhance water quality.
- Protect and/or restore streams, reservoirs, wetlands, and the Bay for the benefit of fish, wildlife, and human uses.
- Develop an implementable stewardship plan based upon an adaptive management approach that uses quantifiable performance measures to ensure continual improvement.
- Ensure that necessary resources are provided for implementation.
- Increase scientific understanding and educational opportunities for all ages. The GSP will be phased, beginning with a Phase I Strategic Plan Feasibility Report. This report will present emerging options for addressing long-term GSP. The Draft Strategic Plan and Feasibility Report will include a Funding Plan for securing resources needed to achieve a sustainable and GSP.

Instream Flow Criteria. The Delta Reform Act required the State Water Resources Control Board (SWRCB) to develop flow criteria for the Delta by 2010 and for CDFW to develop flow criteria and quantifiable biological objectives for aquatic and terrestrial species of concern in the Delta also by 2010. Additionally, the Act required that the SWRCB complete a prioritization schedule for instream flow studies for high priority rivers and streams in the Delta watershed. Since completion of the flow criteria reports (DFG 2010, SWRCB 2010), CDFW has continued to work with the SWRCB to identify new instream flow studies for the high priority rivers and streams in the Delta watershed and on the SWRCB's re-initiated efforts to develop new flow objectives for the San Joaquin River.

Integrated Regional Watershed Planning. Several watershed management plans have been completed due to funding from the CALFED Watershed Program and AFRP. Watershed management plans are a very useful tool for watershed groups and agencies when assessing and prioritizing restoration steps in the tributary watersheds. ERP will consider strategic plans, such as those recently developed by Sacramento River Conservation Area Forum and tributary/watershed assessments and management plans when determining region-wide priorities.

Watershed groups in the Sacramento Valley have completed a huge amount of work in the realm of planning, landowner outreach and coordination, and restoration project implementation, thereby benefiting not only the resources but also the missions of many resource agencies and programs such as ERP. An effective watershed group also provides a forum through which resource agencies can build relationships of trust with other agencies, landowners, and other stakeholders. ERP can support these valuable entities by coordinating with State and Federal watershed management efforts.

Currently numerous local watershed groups within the Sacramento Valley are compiling data for restoration projects within their watersheds. These studies may be compiled and evaluated to determine their relative contribution to the greater Sacramento River watershed. This will allow for more informed decision-making and better protection and use of the resources. The Sacramento River Watershed Program attempts to capture all the various sub-watershed information and has been working toward that goal since 1996. (See: www.sacriver.org).

There is no region-wide monitoring plan to determine success of restoration projects throughout the Sacramento Valley. This makes program-wide and region-wide analysis of success difficult. Project-specific monitoring is not coordinated, i.e., similar projects have different degrees, scales and types of pre- and post-project monitoring, or use different monitoring techniques that make it difficult to cumulatively assess success or failure of comparable projects. Coordination is also needed with other restoration efforts, such as CVPIA, which implements a wide variety of restoration and monitoring projects throughout the Central Valley. Lack of coordination can lead to inefficiency and confounds data analysis. The Conservation Strategy will seek to develop a structure for regional implementation and effectiveness monitoring.

NOAA Fisheries Central Valley Salmon and Steelhead Recovery Plan. The Endangered Species Act (ESA) requires that recovery plans are developed for each species on the Federal list of threatened or endangered species. NOAA Fisheries' recovery planning process for federally listed anadromous salmonids the Central Valley took a key step in 2001 with the formation of a Technical Recovery Team (TRT) composed of federal, state, and academic experts. The TRT was tasked with providing the scientific foundation for recovery planners to use in developing a recovery plan for the Sacramento River winter-run Chinook salmon evolutionarily significant unit (ESU), the Central Valley spring-run Chinook salmon ESU, and the Central Valley steelhead distinct population segment. In 2007, NOAA Fisheries formed a recovery plan team to develop and implement a recovery plan for these three species. Using TRT science products as a foundation, and incorporating co-manager and public input, the recovery plan team developed a Public Draft Recovery Plan that was released in October 2009, commencing a 120-day public comment period. Following that period, NOAA Fisheries has been addressing public comments and working with co-managers to finalize the recovery plan. A Final Recovery Plan is expected to be released in 2013. This document will be a key resource for helping to achieve ERP goals.

This Conservation Strategy and the Recovery Plan share the goal of recovering at risk species. As such, the effectiveness and chances for success of both planning efforts, and others, increases by aligning priorities and coordinating actions. The ERP Implementing Agencies will strive for such coordination and leverage the areas where priorities overlap in order to recover winter-run Chinook salmon, spring-run Chinook salmon, and steelhead.

Pelagic Organism Decline (POD) Studies. Abundance indices calculated by the IEP through 2009 show recent, marked declines in numerous pelagic fishes in the Delta and Suisun Bay (IEP 2007a; Baxter et al 2010). Although several species show evidence of long-term declines, recent low levels were unexpected given the relatively moderate winter-spring flows of the late 1990s and early 2000s. In response to these changes, the IEP formed a POD work team to evaluate the potential causes of the decline. Issues emerging from POD studies, most of which were already identified in ERP documents, emphasize a subset of stressors, namely ecological food web declines and invasive species, toxic pollution, and water operations (IEP 2007b). The POD work team is conducting multiple investigations, including the effects of exotic species on food web dynamics, contaminants, water project operations, and stock recruitment. The most recent POD work plan can be viewed at: http://www.water.ca.gov/iep/

Public Policy Institute of California (PPIC) Reports. PPIC and experts from the University of California, Davis, wrote three reports evaluating the vulnerability of the Sacramento–San Joaquin Delta to a variety of risk factors and describing options for addressing current and likely future problems. The first report, *Envisioning Futures for the Sacramento–San Joaquin Delta* (Lund et al. 2007), describes why the Delta matters to Californians and why the region is currently in a state of crisis. The report concludes with recommendations for several actions, some regarding technical and scientific knowledge, and others regarding governance and finance policies.

The second report, *Comparing Futures for the Sacramento-San Joaquin Delta* (Lund et al. 2008), continued the authors' analysis of future changes to the Delta, and the system's potential responses to those changes. That report focused on which water management strategies would best meet the coequal goals of environmental sustainability and water supply reliability established by the Delta Vision Blue Ribbon Task Force. In comparing different water management alternatives, this report concludes that an isolated conveyance facility is the best option of all the export alternatives for achieving the co-equal goals.

A third report, *Managing California's Water: From Conflict to Reconciliation* (Hanak et al. 2011), also describes why the Delta is currently in a state of crisis. It goes further into what changes need to be made in water policy and water management with recommendations for proposed actions. (See: www.ppic.org/).

Regional Habitat Conservation Plans (HCPs). There are a several HCPs (some of which will also meet the standard of an NCCP) within the Focus Area: the HCP's listed below are in different stages of development or have been completed:

- *Butte Regional HCP/NCCP.* This HCP is under development. The Butte Regional HCP/NCCP is being coordinated by the Butte County Association of Governments (BCAG) on behalf of the City of Biggs, the City of Chico, the City of Gridley, the City of Oroville and the County of Butte. The HCP/NCCP will provide comprehensive species, wetlands and ecosystem conservation and contribute to the recovery of endangered species within the plan area while also providing a more streamlined process for environmental permitting. A planning area has been established for the Butte Regional HCP/NCCP that covers approximately the western half of the county, and includes the entire extent of vernal pool landscapes within Butte County. The planning area provides a focus on the areas of greatest conflict between growth and development and federal and state protected species. The HCP/NCCP will identify where future impacts to protected species will likely occur and will lay out a strategy for avoidance, minimization and mitigation of the natural resources that will be impacted by these activities. The preparation and approval of the HCP/NCCP is expected to be completed by the end of 2012, depending upon the issues that will be addressed and the duration of the State/federal approval process.

- *Eastern Merced Natural Communities Conservation Plan (NCCP).* The County of Merced and University of California are working together to develop an NCCP that will provide conservation of vernal pool habitat and State and federally listed vernal pool endemic species while allowing well planned development of a college campus and associated infrastructure and development. (See: http://www.ucmercedplanning.net/information/finaluclrdpeir.html)

- *Eastern Contra Costa County HCP/NCCP*. This HCP/NCCP, permitted in August 6, 2007, was developed to address indirect and cumulative impacts to terrestrial species from development supported by increases in water supply provided by the Contra Costa Water District. Although the HCP/NCCP planning area includes land within the legal Delta (Water Code §12220 et seq.), the highest priority area for conservation in this HCP/NCCP are lands just west of the Byron Highway. Dutch Slough/Big Break area, lower Marsh Creek, and lower Kellogg Creek are identified as key restoration priorities. Investments in land acquisition and habitat improvements are otherwise focused outside of the legal Delta. Fish species, including salmonids, were not covered in the HCP/NCCP. Impacts to fisheries are addressed through separate ESA/CESA consultation and permitting. (See: www.co.contra-costa.ca.us/depart/cd/water/HCP/documents.html)

- *Natomas Basin Habitat Conservation Plan (NBCHP).* The NBCHP was completed in 2003 and applies to the 53,341-acre interior of the Natomas Basin, located in the northern portion of Sacramento County and the southern portion of Sutter County. The Basin contains incorporated and unincorporated areas within the jurisdiction of the City of Sacramento, Sacramento County and Sutter County. The purpose of the NBHCP is to promote biological conservation along with economic development and the continuation of agriculture within the Natomas Basin. The NBHCP establishes a multi-species conservation program to mitigate the expected loss of habitat values and incidental take of protected species that would result from urban development, operation of irrigation and drainage systems, and rice farming. The goal of the NBHCP is to preserve, restore, and enhance habitat values found in the Natomas Basin while allowing urban development to proceed according to local land use plans. (See: http://www.natomasbasin.org/.)

- *Placer County Conservation Plan (PCCP)*. This HCP/NCCP is in development. The planning area is divided into three phases: Phase I – 273,983 acres of valley floor and low foothills, Phase II – 273,717 acres in the foothills and Martis Valley, Phase III – 412,153 acres of public and private timberlands.

- *San Joaquin County Multi-Species Conservation Plan (SJMSCP).* This HCP/NCCP was approved in 2001. This plan was developed to guide land uses, preserving agriculture, and protecting listed species and other Species of Concern. The geographic scope includes lands within the legal Delta. The SJMSCP provides a strategy for conserving listed species impacted by development and land conversion in San Joaquin County for habitat and agricultural purposes. The plan affects 97 special status species. The SJMSCP currently has a system of 17 preserves totaling 8,683 acres of conserved habitat. (See: www.sjcog.org)

- *San Joaquin Valley Pacific Gas and Electric Operations and Management Habitat Conservation Plan.* This will be the first of a six HCPs to cover PG&E's routine activities throughout the State. The HCP will protect 23 wildlife and 42 plant species including San Joaquin kit fox, California red-legged frog, vernal pool fairy shrimp, and western burrowing owl. Partnerships with local, State, and federal entities are expected to protect 15,000 acres. (See: http://www.pge.com/about/environment/pge/stewardship/habitatconservationplan.shtml)

- *Solano County HCP*. The Solano HCP is under development. A final administrative draft was released in June 2009. It will address species conservation in conjunction with urban development, flood control, and infrastructure improvement activities. Covered species will include Federally- and State-listed fish species and other Species of Concern. The geographic scope includes lands within the legal Delta. (See:www.scwa2.com/Conservation_Habitat_FinalAdminDraft.aspx)

- *South Sacramento County HCP/NCCP.* This HCP/NCCP is under development. The focus of the plan is to protect vernal pool and upland habitats that are being diminished by vineyards and housing development, and conservation of several special status terrestrial species including Swainson's hawk and burrowing owl. The geographic scope generally does not include the Sacramento-San Joaquin Delta portions of Sacramento County; the westernmost boundary of the planning area is Interstate 5. Aquatic species are not addressed by this HCP/NCCP, and have historically been covered by US Army Corps of Engineer and US EPA 404 permits, CDFW Streambed Alteration Agreements, and CEQA documents. Sacramento County is working with the Army Corps of Engineer, US EPA, and CDFW to develop programmatic permits that may be incorporated into the HCP/NCCP. Sacramento County released a draft environmental documentation for this HCP/NCCP in 2010.

(See: http://www.msa2.saccounty.net/planning/Pages/SSHCPPlan.aspx)

- *Yolo County HCP/NCCP.* This county-wide HCP/NCCP is under development. It will provide for the conservation of between 70-80 species in five habitat types: wetland, riparian, oak woodland, grassland and agriculture. No aquatic species are being addressed in this HCP; project-specific mitigation will be developed for projects affecting aquatic resources. Some initial draft chapters are available, and environmental documentation is expected to be initiated in 2010. (See: www.yoloconservationplan.org/.)

- *Yuba-Sutter Regional HCP/NCCP.* This HCP/NCCP is in development.

Riparian Habitat Joint Venture (RHJV). Loss of riparian habitat is the single greatest cause of recent declines in songbird populations in the western U.S. New possibilities for preserving and restoring critical riparian habitat, through partnerships, prompted California Partners In Flight to launch the RHJV in 1994, modeled on the CVJV but funded solely by its member organizations. To date, 18 Federal, State and private organizations have signed the landmark Cooperative Agreement to protect and enhance habitats for native landbirds throughout California. The RHJV, modeled after the successful Joint Venture projects of the North American Waterfowl Management Plan, reinforces other collaborative efforts currently underway which protect biodiversity and enhance natural resources as well as the human element they support.

Riparian Habitat Joint Venture. Current priorities include projects on the Sacramento, Owens, South Fork Kern, San Joaquin, and other California rivers. The Riparian Bird Conservation Plan, which summarizes current scientific knowledge on the requirements of 14 focal bird species, provides recommendations for habitat management, and monitoring. (See: http://www.rhjv.org/)

Sacramento River Bank Protection Program (SRBPP). Projects with a large geographic scope, such as the US Army Corps of Engineers Phase II Sacramento River Bank Protection Project (SacBank) and the DWR Central Valley Flood Management Planning Program (CVFMP) will require similar coordination in order to address the needs of species and habitats that occur in the Sacramento River Valley. SRBBP is a continuing construction project authorized by Section 203 of the Flood Control Act of 1960. Phase II authorizes up to 485,000 linear feet of bank protection and is focused on existing project levees, including the construction of new projects to protect those levees seriously threatened by failure. Development of Phase III of the SRBBP was recently initiated and is expected to be completed by 2013.

Sacramento-San Joaquin River Basins Comprehensive Study. The Comprehensive Study was a joint effort by the California Reclamation Board and United States Army Corps of Engineers (USACE), in coordination with State, Federal, and local agencies, groups, organizations, and the public. The Comprehensive Study focused on balancing and integrating multiple objectives on a local, regional, and system-wide basis by facilitating regional coordination and interaction with other programs. Numerous technical analyses were conducted during the Comprehensive Study to inventory resource conditions in the Planning Area and to analyze problems and opportunities for flood management and ecosystem restoration. The findings of the Comprehensive Study were documented in the December 2002 Interim Report (USACE 2002). They highlighted planning principles that should be used to guide implementation of individual flood management projects and actions in the Central Valley. Technical information and tools developed for the Comprehensive Study have been used by numerous subsequent studies and analyses. (See: http://www.compstudy.net/)

Safe Harbor. The projects funded by ERP involving the agricultural community have not only been beneficial to natural resources, but have also created a better foundation of trust and cooperation between the environmental and agricultural communities. Continuing to actively explore ways in which both communities can work together on restoration that meets the needs of landowners and the resource will be an important step in Stage 2. Many future actions can be targeted at State-owned and other public land within the Sacramento Valley Region. However, it is important to integrate local property rights and landowner concerns in future planning and project implementation. Landowner awareness of implementation practices and their engaged participation in watershed restoration projects is essential. For example, managing the bypasses for the benefit of fish and wildlife must be balanced with use for flood control and farming.

Tools such as Safe Harbor Agreements (SHA) and Habitat Conservation Plans should be used when appropriate. Since 2004, several safe harbor agreements have been developed within the Sacramento Valley Region (in Red Bank Creek and Cottonwood Creek, for example, and a programmatic SHA to be managed by SRCAF). These can be an effective tool to provide habitat for listed species while also addressing landowners' concerns. Senate Bill 448 was signed into law by Governor Schwarzenegger on October 11, 2009. The bill established the California State Safe Harbor Agreement Program Act and adds provisions to the California Fish and Game Code. It became effective on January 1, 2010 and could be used as an additional tool to further conservation efforts.

Additional coordination is needed on the upper portions of watersheds within the Sacramento Valley. A small number of ERP projects addressed restoration needs in the upper elevations of such watersheds as Butte, Mill, Deer, Cow, and Antelope creeks, but more attention is needed to maintain and protect these areas. Most, if not all, of the mid- to high-elevation areas of the Region are under the threat of catastrophic fire impacts. Better coordination is needed to identify resources of concern, particularly in private land areas, as well as address degraded areas. In particular, meadow protection and restoration is urgently needed, as meadows provide habitat for a wide variety of species at higher elevations and improve downstream water quality. Coordination is needed during response to fires in order to inform fire managers of resources at risk, as well as guide restoration efforts. There is a system to provide this service on public lands (U.S. Forest Service and Bureau of Land Management—Burned Area Response and the role of resource advisors on fires) and this model should be explored for the large, undeveloped areas of private land.

San Joaquin River Restoration Program. The San Joaquin River Restoration Program (SJRRP) was established to implement a settlement (Settlement) of an 18-year lawsuit reached in September 2006 by the U.S. Departments of the Interior and Commerce, the Natural Resources Defense Council, and the Friant Water Users Authority (now the Friant Water Authority). Full implementation of the SJRRP will provide sufficient habitat and flow for the reintroduction of spring-run and fall-run Chinook salmon into the San Joaquin River between Friant Dam and the Merced River confluence. The Settlement and the SJRRP has two primary goals: 1) to restore and maintain fish populations in "good condition" in the main stem of the San Joaquin River below Friant Dam to the confluence of the Merced River, including naturally reproducing and self-sustaining populations of salmon and other fish, and 2) to reduce or avoid adverse water supply impacts to all of the Friant Division long-term grantors that may result from the Interim Flows and Restoration Flows provided for in the Settlement (NRDC et al. v Kirk Rodgers et al. 2006). Federal legislation was enacted in March 2009 to authorize and direct the Departments of the Interior and Commerce to implement the Settlement. Although this program is independent of CALFED, many of the agencies and organizations involved were involved with CALFED. The goals of this program are consistent with ERP and though the goal of rebuilding a naturally reproducing and self-sustaining population of spring-run Chinook salmon on the mainstem of the San Joaquin River goes beyond the original goals set for the ERP, it is incorporated within this current strategy and objectives for the SJBPA.

Since the release of the ERPP, the San Joaquin River Restoration Program has been funded and is actively planning restoration of the mainstem of the San Joaquin River above the confluence of the Merced River to Friant Dam. Although not part of the primary geographic area for the ERP, this area shares many problems and potential solutions with the Focus Area and, for these reasons, is included in this Conservation Strategy. In order to implement the settlement, a restoration program has been developed and funded that will focus on the 150 mile segment of the San Joaquin River from the confluence of the Merced River to Friant Dam. The agencies that make up the SJRRP include all of the implementing agencies of the ERP: CDFW, USFWS, and NMFS. In addition to the ERP Implementing Agencies, the agencies implementing the SJRRP include the Reclamation and DWR. Also involved are the Natural Resources Defense Council and the Friant Water Authority; however, these two entities are not directly responsible for implementation activities. There is also formal recognition of the need to establish stakeholder and public outreach activities through a Memorandum of Understanding signed by USBR in 2007. (See: http://www.restoresjr.net/)

San Joaquin Valley Upland Species Recovery Plan. The recovery plan covers 34 species that occur in the San Joaquin Valley, including 11 endangered plant species and five endangered animal species: giant kangaroo rat, Fresno kangaroo rat, Tipton's kangaroo rat, blunt-nosed leopard lizard, and San Joaquin kit fox. The majority of these species occur in San Joaquin Valley grasslands and scrublands and adjacent foothills. The riparian woodrat and riparian brush rabbit occur in riparian areas which also provide critical habitat for neotropical migratory bird species. The ultimate goal of this plan is to delist these eleven listed species. (See: http://ecos.fws.gov/docs/recovery_plan/980930a.pdf)

State and Regional Water Quality Control Boards Bay-Delta Strategic Work plan. The SWRCB and the Central Valley and San Francisco Regional Water Quality Control Boards (Water Boards) completed a *Strategic Work Plan for Activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* in July 2008 (SWRCB 2008). The work plan was written in response to two SWRCB resolutions to describe the actions they will complete to protect the beneficial uses of water in the Bay-Delta estuary. The work plan activities are divided into nine broad elements:

- Water Quality and Contaminant Control
- Comprehensive Delta Monitoring Program
- Southern Delta Salinity and San Joaquin River Flow Objectives
- Suisun Marsh Objectives
- Comprehensive Review of the Bay-Delta Plan, Water Rights, and Other Requirements to Protect Fish and Wildlife Beneficial Uses and the Public Trust
- Methods of Diversion of the State Water Project and the CVP
- Water Right Compliance, Enforcement, and Other Activities to Ensure Adequate Flows to Meet Water Quality Objectives
- Water Use Efficiency for Urban and Agricultural Water Users
- Other Actions

These actions fall within the Water Board's existing responsibilities and authorities. The actions also are responsive to the priorities identified by the Delta Vision, BDCP, Delta Plan, and ERP. The work plan identifies activities that will need to be coordinated with other efforts, such as this Conservation Strategy. (See:http://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/strategic_plan/)

State Water Resources Control Board and Regional Water Quality Control Boards' Bay-Delta Strategic Work Plan. The SWRCB and the Central Valley and San Francisco Regional Water Quality Control Boards (Water Boards) completed a *Strategic Work plan for Activities in the San Francisco Bay/Sacramento-San Joaquin Delta Estuary* in July 2008. The work plan was written in response to two SWRCB resolutions directing the Water Boards to describe actions they would take to protect the beneficial uses of water in the Bay-Delta estuary. The work plan activities include provisions for Southern Delta Salinity and San Joaquin River Flow Objectives. The work plan identifies activities that will need to be coordinated with other efforts, such as the Conservation Strategy. (See: www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/strategic_plan/

State of Bay-Delta Science Report. The CALFED Science Program in 2008 released a report synthesizing the state of scientific knowledge about ecological processes, habitats, stressors, and species in the Delta, as well as about other CALFED program

elements. (Healey et al. 2008; See:
http://www.science.calwater.ca.gov/publications/sbds.html)

The report offers new perspectives on the Delta derived from recent science. These include:

- The Delta is continually changing, so uncontrolled drivers of change (e.g., population growth, land subsidence, and seismicity) mean the future Delta will look very different than that which exists today.
- Because of this continuous change, consequences of management solutions cannot be predicted; solutions will need to be robust but provisional, and responsive and adaptive to future changes.
- It is neither possible nor desirable to "freeze" the Delta in its present or any other form, so strengthening of levees will not be a sustainable solution for all Delta islands.
- The problems of water and environmental management are interlinked, requiring the strong integration of science, knowledge, and management methods.
- The capacity of the system to deliver human, economic, and environmental services is likely at its limit, so tradeoffs must be made – fulfilling more of one water-using service means accepting less of another.
- Good science provides knowledge for decision-making, but for complex environmental problems, new areas of uncertainty will continue to arise as learning continues.
- Climate change dictates that species conservation is no longer simply a local habitat problem, so conservation approaches need to include a broad range of management tools other than habitat restoration.

Suisun Marsh Plan. *The Habitat Management, Preservation, and Restoration Plan for Suisun Marsh* (Suisun Marsh Plan) is being developed by The Suisun Marsh Charter Group Principal Agencies, a team of local, State, and Federal agencies. The Suisun Marsh Plan is focused on protecting and enhancing Suisun Marsh's contributions to the Pacific Flyway and endangered fish and wildlife species habitats, maintaining and improving strategic exterior levees, and restoring tidal marsh and other habitats. The Final programmatic EIS/EIR (PEIS/EIR) was released in 2011 and includes action-specific elements. The authors of the Suisun Marsh Plan anticipate that it can be implemented as a distinct element in any future vision, Conservation Strategy, or implementation plan for the Delta and Suisun Marsh.
(See: www.dfg.ca.gov/delta/suisunmarsh/charter.asp)

The Wildlife Conservation Board (WCB). WCB was created by legislation in 1947 to administer a capital outlay program for wildlife conservation and related public recreation. Originally created within the California Department of Natural Resources, and later placed with CDFW, the WCB is a separate and independent Board with authority and funding to carry out an acquisition and development program for wildlife conservation (DFG Code 1300, et seq.). WCB's three main functions are land acquisition, habitat restoration and the development of wildlife oriented public access facilities. The WCB offers grants under most of its programs. These include grants for restoration and enhancement of wildlife habitat, development of public access facilities for wildlife oriented uses, and protection of habitat through fee acquisitions and conservation easements.

WCB activities are carried out under the following programs, many of which have implemented projects that addressed ERP goals:

- California Forest Conservation Program
- California Riparian Habitat Conservation Program
- Ecosystem Restoration on Agricultural Lands
- Habitat Enhancement and Restoration Program
- Inland Wetlands Conservation Program
- Land Acquisition Program
- Natural Heritage Preservation Tax Credit Program
- Oak Woodlands Conservation Program
- Public Access Program
- Rangeland, Grazing Land, and Grassland Protection Program

Vernalis Adaptive Management Program. The Vernalis Adaptive Management Program (VAMP) was a large-scale, long-term (12-year), experimental/management program that was designed to protect juvenile Chinook salmon migrating from the San Joaquin River through the Sacramento-San Joaquin Delta. VAMP is also a scientifically recognized experiment to determine how salmon survival rates change in flows, and SWP and CVP exports with the installation of the Head of Old River Barrier (HORB). VAMP employed an adaptive management strategy to use current knowledge of hydrology and environmental conditions to protect Chinook salmon smolts, while gathering information to allow more efficient protection in the future. The VAMP program has demonstrated the value of large-scale, long-term, interdisciplinary experimental investigations that provide both protection to fishery resources while also providing important information that can be used to evaluate the performance and biological benefits of various management actions. By adaptively integrating fisheries and hydrology in response to current environmental conditions, the VAMP program has also demonstrated the value of an interdisciplinary approach in the design and successful implementation of management programs. Increasing flows during the spring is indicated as the most effective solution towards doubling the fall-run response to alterations in San Joaquin River Chinook salmon population (Figure 1). The CDFW San Joaquin River Salmon Model V.1.6 analyzes San Joaquin River flows at Vernalis to evaluate flow magnitude and duration scenarios to predict resulting smolt outmigrant populations. (See: http://sanjoaquinbasin.com/vamp-vernalis-adaptive-management-plan.html)

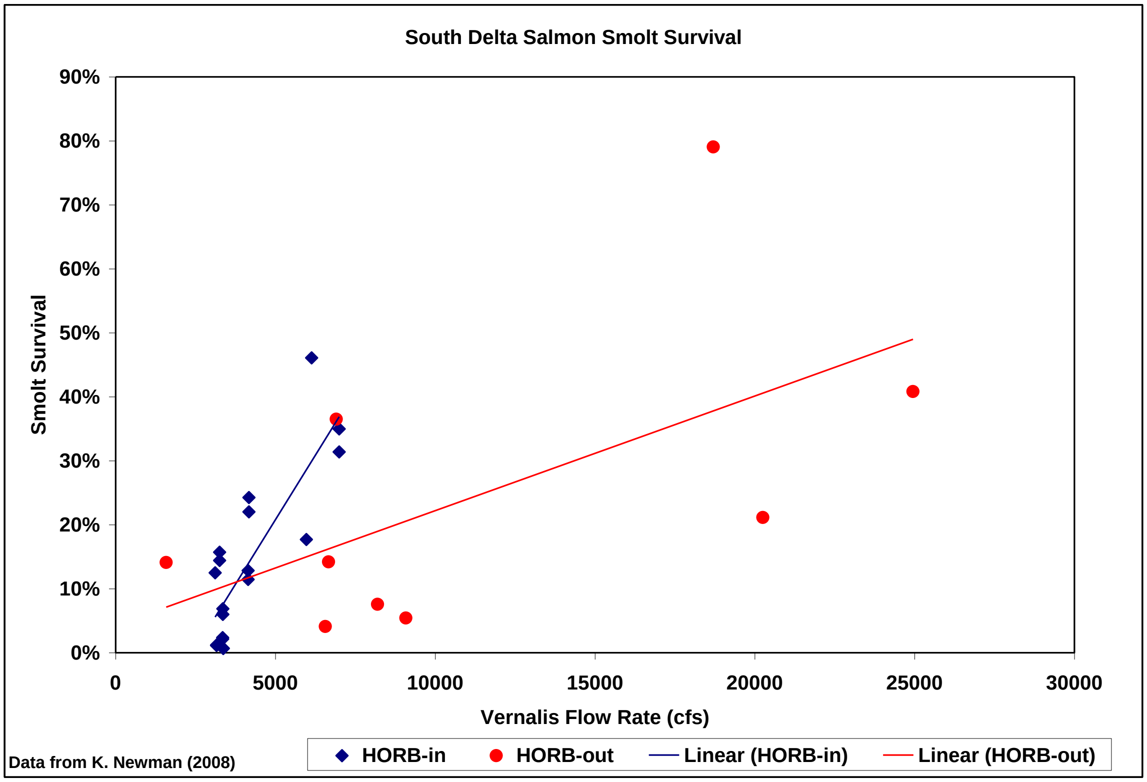

Figure 1: South Delta Juvenile Salmon Survival as a Function of Flow at Vernalis.

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Appendix C – Habitat Crosswalk

The following table provides a crosswalk between habitat categories in the Conservation Strategy map for the Delta and Suisun Planning Area and those in the ERP Plan (2000).

2000 ERP Plan Habitat Categories	ERP Conservation Strategy Map Habitat Categories			
	Intertidal & Subtidal	Floodplain	Upland and Transition Areas	Open Water
Tidal Perennial Aquatic Habitat	X	X		X
Nontidal Perennial Aquatic Habitat		X	X	X
Delta Sloughs (dead-end)	X			
Delta Sloughs (open-ended)	X			
Mid-channel Islands and Shoals	X			
Saline Emergent Wetland	X			
Fresh Emergent Wetland	X	X		
Seasonal Wetlands		X	X	
Riparian and Shaded Riverine Aquatic Habitats		X	X	
Riparian and Riverine Aquatic Habitats (scrub, woodland, forest)	X	X	X	
Freshwater Fish Habitats	X	X		X
Essential Fish Habitats	X	X		X
Inland Dune Scrub Habitat			X	
Perennial Grassland		X	X	
Agriculture Lands (wetlands)			X	
Agriculture Lands (uplands)			X	

Appendix D – Draft Species List for HCP/NCCPs in Delta and Suisun Planning Area[1]

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
PLANTS	Suisun Marsh Aster, *Symphyotrichum lentum* (*Aster lentus*)	X		X				**CNPS 1B.2**
	Ferris's Milk-vetch, *Astragalus tener* var. *ferrisiae*	X						**CNPS 1B.1**
	Alkali Milk-vetch, *Astragalus tener* var. *tener*	X		X			X	**CNPS 1B.2**
	Heartscale, *Atriplex cordulata*	X		X				**CNPS 1B.2**
	Brittlescale, *Atriplex depressa*	X		X	X		X	**CNPS 1B.2**
	San Joaquin Spearscale, *Atriplex joaquiniana*	X			X		X	**CNPS 1B.2**
	Vernal Pool Smallscale, *Atriplex persistens*	X						**CNPS 1B.2**
	Big Tarplant, *Blepharizonia plumosa*				X			**CNPS 1B.1**
	Bristly Sedge, *Carex comosa*			X				**CNPS 2.1**
	Succulent Owl's Clover aka Fleshy Owl's Clover, *Castilleja campestris ssp. succulenta*			X				**FT** **SE** **CNPS 1B.2**
	Slough Thistle, *Cirsium crassicaule*			X				**CNPS 1B.1**
	Suisun Thistle, *Cirsium hydrophilum* var. *hydrophilum*	X						**FE** **CNPS 1B.1**
	Soft Bird's-beak, *Chloropyron molle* ssp. *molle*	X						**FE** **SR** **CNPS 1B.2**
	Palmate-bracted Birds Beak, *Chloropyron palmatum*						X	**FE** **SE** **CNPS 1B.1**
	Recurved Larkspur, *Delphinium recurvatum*	X		X	X			**CNPS 1B.2**
	Dwarf Downingia, *Downingia pusilla*	X				X		**CNPS 2.2**
	Delta Button-celery/Delta Coyote Thistle, *Eryngium racemosum*			X				**SE** **CNPS 1B.1**
	Diamond-petaled (California) Poppy, *Eschscholzia rhombipetala*			X				**CNPS 1B.1**
	Fragrant Fritillary, *Fritillaria liliacea*	X						**CNPS 1B.2**
	Boggs Lake Hedge-hyssop, *Gratiola heterosepala*	X	X			X		**SE** **CNPS 1B.2**
	Hogwallow Starfish, *Hesperevax caulescens*	X						**CNPS 4.2**

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	Wooly Rose-mallow, *Hibiscus lasiocarpus occidentalis*	X			X			**CNPS 1B.2**
	Carquinez Goldenbush, *Isocoma arguta*	X						**CNPS 1B.1**
	Ahart's Dwarf Rush, *Juncus leiospermus* var. *ahartii*					X		**CNPS 1B.2**
	Ferris's Goldfields, *Lasthenia ferrisiae*	X						**CNPS 4.2**
	Delta Tule Pea, *Lathyrus jepsonii* var. *jepsonii*	X	X	X				**CNPS 1B.2**
	Legenere, *Legenere limosa*	X	X	X		X		**CNPS 1B.1**
	Heckard's Pepper-grass, *Lepidium latipes var. heckardii*	X					X	**CNPS 1B.2**
	Mason's Lilaeopsis, *Lilaeopsis masonii*	X		X				**SR** **CNPS 1B.1**
	Delta Mudwort, *Limosella subulata*	X		X				**CNPS 2.1**
	Showy Madia, *Madia radiata*			X	X			**CNPS 1B.1**
	Cotula Navarretia, *Navarretia cotulifolia*	X						**CNPS 4.2**
	Baker's Navarretia, *Navarretia leucocephala* ssp. *bakeri*	X						**CNPS 1B.1**
	Pincushion Navarretia, *Navarretia myersii* spp. *myersii*					X		**CNPS 1B.1**
	Adobe Navarretia *Navarretia nigelliformis* ssp. *nigelliformis*				X			**CNPS 4.2**
	Colusa Grass, *Neostapfia colusana*	X	X				X	**FT** **SE** **CNPS 1B.1**
	Slender Orcutt Grass, *Orcuttia tenuis*		X			X		**FT** **SE** **CNPS 1B.1**
	Sacramento Orcutt Grass, *Orcuttia viscida*		X			X		**FE** **SE** **CNPS 1B.1**
	San Joaquin Valley Orcutt Grass, *Orcuttia inaequalis*	X						**FT** **SE** **CNPS 1B.1**
	Gairdner's Yampah, *Perideridia gairdneri* ssp. *gairdneri*	X						**CNPS 4.2**
	Marin Knotweed, *Polygonum marinense*	X						**CNPS 3.1**

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	Delta Woolly-marbles, *Psilocarphus brevissimus* var. *multiflorus*	X						CNPS 4.2
	Lobb's Aquatic Buttercup, *Ranunculus lobbii*	X						CNPS 4.2
	Sanford's Arrowhead (Sagittaria), *Sagittaria sanfordii*		X	X		X		CNPS 1B.2
	Side-flowering Skullcap, *Scutellaria lateriflora*			X				CNPS 2.2
	Chaparral Ragwort, *Senecio aphanactis*	X						CNPS 2.2
	Wright's Trichocoronis, *Trichocoronis wrightii* var. *wrightii*			X				CNPS 2.1
	Saline Clover, *Trifolium depauperatum* var. *hydrophilum*	X						CNPS 1B.2
	Caper-fruited Tropidocarpum, *Tropidocarpum capparideum*			X				CNPS 1B.1
	Greene's Tuctoria, Tuctoria greenei			X				FE SR CNPS 1B.1
	Crampton's Tuctoria, (Solano Grass), *Tuctoria mucronata*	X					X	FE SE CNPS 1B.1
ANIMALS	BIRDS							
	Cooper's Hawk, *Accipiter cooperii*	X		X		X	X	CA WL
	Sharp-shinned Hawk, *Accipiter striatus*	X		X		X		CA WL
	Western Grebe, *Aechmophorus occidentalis*			X				None
	Tricolored Blackbird *Agelaius tricolor*	X	X	X	X	X	X	CA WL
	Bell's sage sparrow, *Amphispiza belli belli*			X				CA WL
	Golden Eagle, *Aquila chrysaetos*	X		X	X	X		CA SSC
	Great Egret, *Ardea alba* (rookery)			X				
	Great blue Heron, *Ardea herodias* (rookery)			X				CA SA
	Short-eared Owl *Asio flammeus*	X				X	X	CA SSC
	Long-eared Owl, *Asio otus*					X		CA SSC
	Burrowing Owl, *Athene cunicularia*	X	X		X	X	X	CA SSC
	Aleutian Canada Goose, *Branta hutchinsii leucopareia*		X	X				F DL
	Ferruginous Hawk, *Buteo regalis*					X		CA WL
	Swainson's Hawk, *Buteo swainsoni*	X	X	X	X	X	X	ST
	Northern Harrier, *Circus cyaneus*	X				X	X	CA SSC
	Mountain Plover *Charadrius montanus*	X		X				PT

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
								CA SSC
	Western Yellow-billed Cuckoo, *Coccyzus americanus occidentalis*			**X**			**X**	**FC** **SE**
	California Yellow Warbler, *Dendroica petechia brewsteri*						**X**	**CA SSC**
	White-tailed Kite, *Elanus leucurus*					**X**		**CA FP**
	Merlin, *Falco columbarius*					**X**		**CA FP**
	American Peregrine Falcon, *Falco peregrinus anatum*		**X**			**X**		**CA FP**
	Salt Marsh Common Yellowthroat, *Geothlypis trichas sinuosa*	**X**						**CA SSC**
	Greater Sandhill Crane, *Grus canadensis tabida*		**X**	**X**		**X**		**ST** **CA FP**
	Bald Eagle, *Haliaeetus leucocephalus*					**X**		**F DL** **SE** **CA FP**
	Yellow-breasted Chat, *Icteria virens*	**X**				**X**		**CA SSC**
	Loggerhead Shrike, *Lanius ludovicianus*		**X**			**X**	**X**	**CA SSC**
	California Black Rail *Laterallus jamaicensis coturniculus*	**X**		**X**				**ST** **CA FP**
	Suisun Song Sparrow, *Melospiza melodia maxillaris*	**X**						**CA SSC**
	White-faced Ibis, *Plegadis chihi*		**X**			**X**	**X**	**CA WL**
	California Clapper Rail, *Rallus longirostris obsoletus*	**X**						**FE** **SE** **CA FP**
	Bank swallow, *Riparia riparia*		**X**	**X**			**X**	**ST**
	AMPHIBIANS							
	California Tiger Salamander, *Ambystoma californiense*	**X**	**X**	**X**	**X**	**X**	**X**	**FT** **ST** **CA SSC**
	Foothill Yellow-legged Frog, *Rana boylii*	**X**		**X**	**X**		**X**	**CA SSC**
	California Red-legged frog, *Rana draytonii*							**FT** **CA SSC**
	Western Spadefoot, *Spea hammondii*		**X**			**X**	**X**	**CA SSC**
	REPTILES							
	Western Pond Turtle, *Emys marmorata*	**X**	**X**	**X**	**X**	**X**	**X**	**CA SSC**
	Silvery Legless Lizard, *Anniella pulchra pulchra*				**X**			**CA SSC**
	San Joaquin Whipsnake, *Masticophis flagellum ruddocki*			**X**				**CA SSC**

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	Alameda Whipsnake, *Masticophis lateralis euryxanthus*				X			**FT** **ST**
	Giant Garter Snake, *Thamnophis gigas*	X	X	X	X	X	X	**FT** **ST**
	MAMMALS							
	Pallid bat, *Antrozous pallidus*					X		**CA SSC**
	Ringtail, *Bassariscus astutus*					X		**CA FP**
	Townsend's Western Big-eared Bat, *Corynorhinus townsendii townsendii*				X			**CA SSC**
	Western Red Bat, *Lasiurus blossevillii*					X		**CA SSC**
	Yuma Myotis Bat, *Myotis yumanensis*					X		**None**
	Riparian Woodrat, *Neotoma fuscipes riparia*			X				**FE** **CA SSC**
	Salt Marsh Harvest Mouse, *Reithrodontomys raviventris*	X						**FE** **SE** **CA FP**
	Suisun Ornate Shrew, *Sorex ornatus sinuosus*	X						**F SSC** **CA SSC**
	Riparian Brush Rabbit, *Sylvilagus bachmani riparius*			X				**FE** **SE**
	American Badger, *Taxidea taxus*					X		**CA SSC**
	San Joaquin Kit Fox, *Vulpes macrotis mutica*			X	X			**FE** **ST**
	INVERTEBRATES							
	Ciervo Aegialian Scarab Beetle, *Aegialia concinna*			X				**None**
	Conservancy Fairy Shrimp, *Branchinecta conservatio*	X	X	X	X		X	**FE**
	Vernal Pool Fairy Shrimp, *Branchinecta lynchi*	X		X	X	X	X	**FT**
	Longhorn Fairy Shrimp, *Branchinecta longiantenna*		X	X	X			**FE**
	Mid Valley Fairy Shrimp, *Branchinecta mesovallensis*	X	X	X	X	X	X	**None**
	Valley Elderberry Longhorn Beetle, *Desmocerus californicus dimorphus*	X	X	X		X	X	**FT**
	Delta Green Ground Beetle, *Elaphrus viridis*	X						**FT**
	Curved-foot Diving Beetle, *Hygrotus curvipes*			X				**None**
	Ricksecker's Water Beetle, *Hydrochara*	X				X		**None**

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	rickseckeri							
	Vernal Pool Tadpole Shrimp, *Lepidurus packardi*	**X**	**X**	**X**	**X**	**X**	**X**	**FE**
	Callippe Silverspot Butterfly, *Speyeria callippe callippe*	**X**						**FE**
	FISH							
	Green Sturgeon, *Acipenser medirostris*			**X**				**FT** **CA SSC**
	Delta Smelt, *Hypomesus transpacificus*	**X**		**X**				**FT** **SE**
	Chinook Salmon - Winter-run, *Oncorhynchus tshawytscha*	**X**						**FE** **SE**
	Chinook Salmon-Central Valley fall/late fall-run ESU, *Oncorhynchus tshawytscha*	**X**						**CA SSC**
	Chinook Salmon - Spring-run, *Oncorhynchus tshawytscha*	**X**						**FT** **ST**
	Steelhead - Central Valley DPS, *Oncorhynchus mykiss irideus*	**X**						**FT**
	Sacramento Splittail, *Pogonichthys macrolepidotus*	**X**		**X**				**FT**
	Longfin Smelt, *Spirinchus thaleichthys*			**X**				**FT** **CA SSC**

[1]Nomenclature is from CNDDB Special Animals List (January 2011 list) and Special Plants List (January 2012 list)

Plant Ranking System

The CDFW **California Natural Diversity Database Listing System**

www.dfg.ca.gov/wildlife/nongame/list.html

SR	State-Listed Rare
ST	State-Listed Threatened
SE	State-Listed Endangered
FT	Federally-Listed Threatened
FE	Federally-Listed Endangered

The California Native Plant Society Ranking System

http://www.cnps.org/cnps/rareplants/ranking.php

List 1A: Plants Presumed Extinct in California
List 1B: Plants Rare, Threatened, or Endangered in California and Elsewhere
List 2: Plants Rare, Threatened, or Endangered in California, But More Common Elsewhere
List 3: Plants About Which We Need More Information - A Review List
List 4: Plants of Limited Distribution - A Watch List

Threat Ranks

0.1-Seriously threatened in California (high degree/immediacy of threat)
0.2-Fairly threatened in California (moderate degree/immediacy of threat)
0.3-Not very threatened in California (low degree/immediacy of threats or no current threats known)

Animal Ranking System

http://www.dfg.ca.gov/wildlife/nongame/

State Listings

ST	State-Listed Threatened
SE	State-Listed Endangered
CA SSC	California Species of Special Concern
CA FP	California Fully Protected
CA SA	California Special Animal
CA WL	California Watch List
CNDDB	Listed in California Natural Diversity Database

Federal Listings

FT	Federally-Listed Threatened
FE	Federally-Listed Endangered
P(T/E)	Proposed Threatened or Endangered
FC	Federal Canidate Species
F DL	Federally De-listed
F SSC	Federal Species of Special Concern
ESU	Evolutionary Significant Unit
DPS	Distinct Population Segment

Appendix E – Stage 2 Foundation Documents

Ecosystem Restoration Program Plan (ERPP). The ERPP consists of four volumes: Volume 1 presents visions for the ecosystem elements in the Central Valley that serve as the ERP foundation and scientific basis. Volume 2 of the ERPP presents visions for the 14 ecological management zones and their respective ecological management units. The vision statement for each ecological management zone vision contains a brief description of the management zone and units, important ecological functions associated with the zone, significant habitats, species that use the habitats and stressors that impair the functioning or use of the processes and habitats. ERPP Volume 2 also contains restoration targets, programmatic actions, the rationale for targets and actions, and conservation measures that balance and integrate ERP implementation with the needs of the MSCS. Volume 3 of the ERPP is the Strategic Plan. Volume 4 contains maps of the ERP ecological management zones and units. (See: http://www.dfg.ca.gov/ERP/reports_docs.asp)

Advantages of an Ecosystem-Based Approach over the Traditional Species-Based Approach

- Restoration of physical processes reproduces subtle elements of ecosystem structure and function in addition to the more obvious elements, thereby possibly enhancing the quality of restored habitat.
- Restoration of physical processes can benefit not only threatened and endangered species, but also unlisted species, thereby reducing the likelihood of future listings.
- Restoration of physical processes reduces the need for ongoing human intervention to sustain remnant or restored habitats.
- Restoration of physical processes may produce a more resilient ecosystem capable of withstanding future disturbances.

ERP Strategic Plan 2000

ERP Strategic Plan. The ERP Strategic Plan in Volume 3 contains six strategic goals that define the scope of the program. These goals are divided further into more specific objectives, each of which is intended to help determine whether or not progress is being made toward achieving the respective goal. Specific actions based on the ERPP are identified in the ERP Strategic Plan.

Progress on these goals and objectives over the years has been varied. ERP has made progress on some, especially those relating to habitat restoration, but others have not fared as well, particularly the objectives related to protecting and recovering at-risk Delta aquatic species. Some of these species have declined since 2000; for example, the POD Action Plan includes the listed Delta smelt and longfin smelt (IEP 2007). The Stage 1 evaluation shows that some ERP activities during Stage 1 have benefited at-risk species by:

- enabling a better understanding of important processes such as hydrodynamics, temperature regimes, and instream flow,
- assessing hatchery impacts on natural Chinook salmon and steelhead populations,
- developing a methodology to culture all life stages of delta smelt,
- assessing various contaminant effects on aquatic species,

- planning and implementing restoration of aquatic and terrestrial habitat,
- increasing understanding of salmonid populations through monitoring and genetic studies, and
- increasing understanding of the value of floodplains to native fish species.

> **CALFED Record of Decision (ROD) Representative Ecosystem Restoration Program Actions**
>
> - Protecting, restoring, and managing diverse habitat types representative of the Bay-Delta and its watershed.
> - Acquiring water from sources throughout the Bay-Delta's watershed to provide flows and habitat conditions for fishery protection and recovery.
> - Restoring critical in-stream and channel-forming flows in Bay-Delta tributaries.
> - Improving Delta outflow during key periods.
> - Reconnecting Bay-Delta tributaries with their floodplains through the construction of setback levees, the acquisition of easements, and the construction and management of flood bypasses for both habitat restoration and flood protection.
> - Developing assessment, prevention and control programs for invasive species.
> - Restoring aspects of the sediment regime by relocating in-stream and floodplain gravel mining, and by artificially introducing gravels to compensate for sediment trapped by dams.
> - Modifying or eliminating fish passage barriers, including the removal of some dams, construction of fish ladders, and construction of fish screens that use the best available technology.
> - Targeting research to provide information that is needed to define problems sufficiently, and to design and prioritize restoration actions.
>
> *CALFED ROD 2000*

CALFED Multi-Species Conservation Strategy. The MSCS was designed to meet the requirements of the federal Endangered Species Act (ESA), California Endangered Species Act (CESA), and the Natural Community Conservation Planning Act (NCCPA). The MSCS provides a programmatic approach for evaluating potential impacts of CALFED projects on specified biological resources, similarly a programmatic environmental impact document prepared under the requirements of the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). (See: http://www.dfg.ca.gov/ERP/reports_docs.asp).

The MSCS identified and evaluated 244 special status species and 20 natural communities that could be affected by CALFED program implementation. Conservation goals for each species and community were identified. Species goals are: 1) recovery of 19 listed species (these are known as the "R" species); 2) contribute to recovery of populations for 25 special status species (these are known as the "r" species), and 3) maintain existing levels of populations and habitats for 155 sensitive species (these are known as the "m" species). Goals for natural communities fall into four categories: 1) substantially increase extent and quality of habitat; 2) protect, enhance, and restore habitat; 3) avoid, minimize, and compensate for habitat loss; and 4) avoid, minimize, and compensate for loss of individuals where evaluated species are affected.

Record of Decision. In August of 2000, the Record of Decision (ROD) was signed for the CALFED Bay-Delta Program. The CALFED Program includes 11 program elements that collectively are intended to improve the health and sustainability of the Bay-Delta ecosystem so that it is a more reliable source of drinking water and irrigation water for 22 million Californians and 7.5 million acres of agricultural land. In 2006, the CDFW was designated the implementing agency for the CALFED Bay-Delta Program Ecological Restoration Program (Water Code §79441(c)) assuming that responsibility from the California Bay-Delta Authority. (See: http://www.dfg.ca.gov/ERP/envcomp_rod.asp)

References

Interagency Ecological Program (IEP). 2007. Pelagic Organism Decline. Interagency Ecological Program, CALFED Bay-Delta Program. Available: http://science.calwater.ca.gov/pod/pod_index.shtml (August 2007).