6. FISH, WILDLIFE AND PLANT SPECIES

Introduction

The geographic scope of the ERP is defined by the interdependence and linkage of the ecological zones which encompass the Central Valley. These ecological zones include the upland river-riparian systems, alluvial river-riparian systems, the Delta, and Greater San Francisco Bay. The geographic scope also defines locations where restoration actions might be implemented to maintain, protect, restore, or enhance important ecological processes, habitats, and species. Some rivers or watersheds have ecological attributes which are valued higher than the attributes of others areas. These ecological values include the condition of important ecological processes and how well they support a diversity of habitats and biotic communities. The communities include the fish, wildlife, and plants which occupy or utilize the habitats within these local areas.

The species addressed in the ERP depend on habitat conditions in Suisun Bay, the Delta, Sacramento River, San Joaquin River, and many of their tributary streams. For these reasons, the primary geographic focus of the ERP is the Sacramento-San Joaquin Delta, Suisun Bay, the Sacramento River below Shasta Dam, the San Joaquin River below the confluence with the Merced River, and their major tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. In addition, streams such as Mill Creek, Deer Creek, Cottonwood Creek, and Cosumnes River, are emphasized due to their free-flowing status and relative high quality of habitats and ecological processes.

The Multi-Species Conservation Strategy (MSCS) addresses all federally- and State-listed, proposed, and candidate species that may be affected by the CALFED Program. Additional species identified by CALFED that may be affected by the Program and for which adequate information is available also are addressed in the MSCS. The term “evaluated species” refers to all of the species addressed by the Conservation Strategy. Please refer to the MSCS appendix (CALFED 2000) for more information and for a complete list of evaluated species. The species classifications used in the ERP include the MSCS designations of 1) recovery, 2) contribute to recovery, and 3) maintain. Two additional designations were developed to cover other species addressed by the ERP. These include 4) enhance and/or conserve, and 5) maintain and/or enhance harvested species.

The descriptions of the MSCS and ERP species designations follow:

RECOVERY “R”: For species designated “R,” CALFED has established a goal to recover the species within the CALFED ERP Ecological Management Zones. A goal of “recovery” was assigned to those species whose recovery depends on restoration of the Delta and

Suisun Bay/Marsh ecosystems and for which CALFED could reasonably be expected to undertake all or most of the actions necessary to recover the species. Recovery is achieved when the decline of a species is arrested or reversed, threats to the species are neutralized, and thus, the species' long-term survival in nature is assured.

Recovery is equivalent, at a minimum, to the requirements for delisting a species under FESA and CESA. Certain species, such as anadromous fish, have threats outside the geographic scope or purview of the CALFED Program (i.e. ocean harvest regulated by the Magnuson-Stevens Act). Therefore, in some instances CALFED may not be able to complete all actions potentially needed to recover the species. CALFED will, however, implement all necessary recovery actions within the ERP Ecological Management Zones. For other species, CALFED aims to achieve more than would be required for delisting (e.g. restoration of a species and/or its habitat to a level beyond delisting requirements). The effort required to achieve the goal of "recovery" may be highly variable between species. In sum, to achieve a goal of "recovery" implies that CALFED is expected to undertake all actions within the ERP Ecological Management Zones and Program scope necessary to recover the species.

CONTRIBUTE TO RECOVERY ("r"): For species designated "r," CALFED will make specific contributions toward the recovery of the species. The goal "contribute to recovery" was assigned to species for which CALFED Program actions affect only a limited portion of the species range and/or for which CALFED Program actions have limited effects on the species.

To achieve the goal of contributing to a species' recovery, CALFED is expected to undertake some of the actions under its control and within its scope that are necessary to recover the species. When a species has a recovery plan, CALFED may implement some of the measures identified in the plan that are within the CALFED Problem Area, and some measures that are outside the Problem Area. For species without a recovery plan, CALFED would need to implement specific measures that would benefit the species.

MAINTAIN ("M"): For species designated "m," the CALFED Program will undertake actions to maintain the species. This category is less rigorous than "contribute to recovery." For this category, CALFED will avoid, minimize, and compensate for any adverse effects to the species commensurate with the level of effect on the species. Actions do not actually have to contribute to the recovery of the species; however, at a minimum, they will be expected not to contribute to the need to list an unlisted species or degrade the status of an already listed species. CALFED will also, to the extent practicable, improve habitat conditions for these species.

ENHANCE AND/OR CONSERVE"E": For those biotic assemblages and communities (aquatic, terrestrial, and plant) designated "E", the CALFED Program will undertake actions to maintain and enhance their diversity, distribution and abundance in the Bay-

Delta estuary and watershed as appropriate to reverse their declines or to keep abundances and distributions at their present levels.

MAINTAIN AND/OR ENHANCE HARVESTED SPECIES (“H”): For those species designated “H” the CALFED Program will undertake actions to maintain the species at levels which support viable harvest rates. The goal “maintain harvested species” was assigned to species which are harvested for recreational or commercial purposes. A key to maintaining harvestable surplus levels is recognizing the need to recover, contribute to recovery, or maintain species evaluated in the MSCS. Thus, species interactions such as competition and predation and habitat needs for space and flow need to be balanced in favor of species designated for recovery, contribute to recovery and maintain. Those three designations apply only to native species and assemblages while the “maintain harvested species” designation includes some native species and non-native species. An actions taken to maintain harvested species should, at a minimum, not contribute to the need to list an unlisted species; degrade the status of an already listed species; or impair in any way efforts to recover, contribute to recovery, or maintain native species.

Some species, such as Chinook salmon and steelhead trout, are covered by more than one strategic objective. For example, both Chinook and steelhead are at-risk species and harvested species and thus covered by the objective to achieve recovery, first, and then large self-sustaining populations; as well as the objective to enhance fisheries for Chinook, steelhead, white sturgeon, Pacific herring, and native cyprinid fishes.

Stage 1 implementation primarily addressed the MSCS “Recovery” species, though a diversity of species in the other designations also benefited from ERP implementation. The “Recovery” species are listed below.

Table 1. Species Designation Recovery (“R”): For those species designated “R”, the CALFED Program has established a goal to recover the species within the CALFED ERP Ecological Management Zones.

Strategic Plan Objective: Achieve, first, recovery and then large self-sustaining populations of the following at-risk native species dependent on the Delta, Suisun Bay, and Suisun Bay:	
Delta Smelt	Suisun Marsh Aster
Longfin Smelt	Suisun Thistle
Green Sturgeon	Soft Bird’s-Beak
Splittail	Antioch Dunes Evening-Primrose
Sacramento Winter-Run Chinook Salmon ESU	Contra Costa Wallflower
Sacramento Spring-Run Chinook Salmon ESU	Lange’s Metalmark Butterfly
Fall-run Chinook Salmon ESU including Late-Fall	Valley Elderberry Longhorn Beetle
Run Chinook Salmon	Suisun Ornate Shrew
Central Valley Steelhead Trout ESU	Suisun Song Sparrow
Mason’s Lilaeopsis	San Pablo Song Sparrow

The CALFED Ecosystem Restoration Program (ERP) emphasized the need for improving ecological processes, restoring habitats, and reducing stressors, to achieve species recovery on a broader scale than could be achieved by implementing species-specific recovery actions. ERP (and the CALFED program in general) strove to use "adaptive management"; this approach allows for flexibility in decision-making and program implementation in light of uncertainties and new information. Such an approach requires, as a first step, the creation of conceptual models that capture the most recent understanding of ecological processes, habitats, stressors, and species interactions within the system; these models are then used to test hypotheses on how different management decisions or actions might play out in the system.

Numerous projects funded by ERP over the years were classified as "research" projects, including funding allocations for studies focused on individual species. This information addressed needs identified in CALFED's proposed Comprehensive Monitoring Assessment and Research Program (CMARP), which called out the development of conceptual models as the first step in evaluating key issues related to ecosystem restoration and adaptive management, by allowing scientists to present their current understanding of key ecosystem relationships and then identify major issues or data gaps that need to be addressed to better understand those relationships. Although one contract (**ERP-98-C10**) was funded to initiate the *Comprehensive Monitoring and Assessment Research Program (CMARP)*, CMARP was never implemented as envisioned. However, ERP funding has been instrumental in aiding the development and refinement of numerous conceptual models of species' life histories and their interactions with ecosystem processes, habitats, and stressors. These models are being developed under the program formerly known as the Delta Regional Ecosystem Restoration Implementation Plan (DRERIP). These conceptual models are increasingly important, as they are believed to represent the most up-to-date scientific understanding of species and their interactions in the system. It is envisioned that the various Delta planning processes underway (e.g. Delta Vision Process, Delta Risk Management Strategy, the ERP Conservation Strategy, and the Bay-Delta Conservation Plan) will use these conceptual models when evaluating future management of the Delta for ecosystem and water supply uses. Following is a list of conceptual models which are in various stages of development:

Table 2. DRERIP Conceptual Models

Species	Habitats
Delta smelt	Tidal Marsh
Longfin smelt	Perennial Aquatic
Salmonids (Chinook [4 runs] and Steelhead)	Aquatic Vegetation
Splittail	Managed Wetlands
Sturgeon (Green & White)	Riparian

Table 2. DRERIP Conceptual Models

Species	Habitats
Lange's Metalmark butterfly	Floodplains
Invasive clams	Open water
Warm water centrarchids	
Processes	**Stressors**
Hydrodynamics/Transport	Boundary conditions
Sediment	Toxicity
Organic Carbon	Selenium
Aquatic Food Web	Mercury and Methylmercury
Low Dissolved Oxygen	Pyrethroids
Temperature	

Source: ftp://ftp.delta.dfg.ca.gov/; status table last updated 12/12/07.

A few of these conceptual models are complete. Most of the rest are in various stages of development or undergoing peer review. It is hoped that most of the conceptual models will be ready for distribution and use by August of 2008.

While numerous ERP-funded projects addressed specific stressors (such as water diversions or contaminants) that impact fish populations, the remainder of this chapter will refer to the goals and achievements of the ERP program as they relate to species themselves (specific processes, habitats, and stressors are covered elsewhere in this report).

References

CALFED Bay-Delta Program. 2000. Ecosystem Restoration Program: Multi-Species Conservation Strategy. Final Programmatic EIS/EIR Technical Appendix. July 2000.

6. FISH, WILDLIFE AND PLANT SPECIES

6.1 Delta Smelt

Introduction

Delta smelt (*Hypomesus transpacificus*) is a MSCS "Recovery" species. The delta smelt is a native estuarine resident fish found mainly in the Sacramento-San Joaquin Delta and in Suisun and San Pablo Bays. Delta smelt abundance is highest in Montezuma Slough, Suisun Bay, and the western Delta; but beginning in December, and continuing through late June, they migrate upstream and are more abundant in the Delta. Human-caused impacts have reduced habitat quality which in turn has reduced delta smelt populations. This led to the delta smelt being listed as Threatened under the State and federal Endangered Species Acts.

Low Delta outflow, poor food web productivity, reduced low-salinity habitat, losses to water diversions, poor spawning habitat, and higher concentrations of toxins all have adverse effects on this species.

Delta smelt represent an important component of the historic native fish fauna and Bay-Delta food web (i.e. as prey for species such as Chinook salmon). Its short life span, relatively low reproductive rate, and a limited diet make its population abundance sensitive to short-term habitat changes. As a consequence, the delta smelt abundance is characterized by sharp declines followed by dramatic recovery. Low abundance through the drought years (1987-1992) indicated the need for actions to restore the delta smelt population (CALFED 2000).

Applicable ERP Vision

The vision for delta smelt is to recover this State- and federally-listed threatened species in order to contribute to the overall species richness and diversity of the Bay-Delta and to improve water management for beneficial uses of the Bay-Delta system.

The strategic objective for delta smelt is to achieve recovery and then large self-sustaining populations of this at-risk species dependent on the Delta, Suisun Bay, and Suisun Marsh. Long and short-term objectives are, respectively, to restore delta smelt abundance to levels that existed in the 1960s and 1970s (as measured over a period of at least ten years) and to achieve the recovery goals for delta smelt identified in the Delta Native Fishes Recovery Plan (CALFED 2000).

Stage 1 Expectations

The expectation for Stage 1 was that in seven to ten years, the delta smelt population indices should be within the same range as during 1990-1998, and that the basic factors limiting delta smelt distribution and abundance should be determined (e.g. reduced food supply, interactions with non-native species, negative effects of diversions) and, where feasible, overcome through habitat and ecosystem process restoration. General targets for delta smelt include exceeding a fall midwater trawl catch index of 240 in dry water-year types and a wider distribution of delta smelt in the trawl survey.

Comprehensive Monitoring Assessment and Research Program (CMARP)

In addition to the visions and targets within the ERPP, the CMARP technical appendix identifies some possible implementation actions specific to delta smelt. It identified a need for additional monitoring (i.e. improved monitoring and delineation of spawning habitat, and additional larval monitoring in the Delta and Suisun Bay). CMARP also identified the following areas of emphasis for the proposed delta smelt research program:

- studies of basic biology and physiology
- studies of habitat extent and quality
- studies of growth and condition
- integrated monitoring studies of larval transport and recruitment processes

The CMARP Steering Committee recommended that an interdisciplinary agency/stakeholder work team use the results of the 3rd Delta Smelt Workshop to determine whether additional research on delta smelt was needed in support of CALFED goals and adaptive management, and to develop a prioritized list of needed studies.

Changes Attributable to ERP

The restoration of natural processes (e.g. adequate instream flows and temperatures), restoration of habitats, and elimination of stressors (i.e. water diversions and non-native invasive species), covered in other chapters of this report, speak to the causes, rather than just the symptoms, of delta smelt population declines, and should continue to be the focus of restoration efforts.

In accordance with the implementation actions laid out in the ERP and CMARP documents, ERP has funded several studies and monitoring efforts for delta smelt.

The ERP provided funding for three *Delta Smelt Culture and Research Program* contracts (**ERP-98-C02**, **ERP-00-B03**, and **ERP-02-P31**) with researchers at the

University of California, Davis. The objective of these projects was to develop methods to culture all life stages of delta smelt, so that additional research (e.g. toxicity testing, fish screen design work) could be conducted without further harm to the natural population. The cultured fish are also intended to serve as a refuge population in the case of a continued decline in the natural population.

Results from the delta smelt culture studies also enabled researchers to determine that larval smelt and juveniles respond differently to the thermal environment (larvae grew best at 17'C whereas juveniles grew best at 20'C), and to develop optimal growth curves for the early larval and the juvenile life stages. Over several years of funding to this program, the researchers were able to develop reliable methodologies for culturing delta smelt which significantly improved spawning efficiency. As natural smelt populations have been declining, the number of eggs produced and the number of hatched larvae per female in the laboratory has been increasing; this is due to the development of in-vitro fertilization and a new incubator design in the lab. The expanded delta smelt culture facility is capable of producing more than 20,000 fish from 2,000 delta smelt caught in the wild (Castillo 2006).

ERP also provided funding to another group of researchers from U.C. Davis tasked with evaluating the overall health, condition, and growth rate of delta smelt samples collected from various habitats by the Interagency Ecological Program (IEP), a multi-agency effort that conducts cooperative ecological investigations in San Francisco Bay and the Sacramento-San Joaquin Delta (*Role of Contaminants in the Decline of Delta smelt in the Sacramento-San Joaquin Estuary* (**ERP-97-C06**). Contaminant effects on individual smelt were determined by analyzing the IEP samples for histopathology biomarkers of exposure and organ/tissue condition, and biomarkers of DNA damage with otolith growth rate analyses. Data analysis efforts were focused on samples collected in spring (when pesticides and food availability affects larvae and juveniles) and early fall (when food availability due to density dependence affects juveniles and pre-adults). Results of the study indicated that 10% of samples collected in both spring 1999 and fall 2000 were impacted by pesticides. 30% of samples collected in spring 1999 experienced poor growth, and 60% of samples collected in fall 2000 experienced poor growth. This particular study is one component of what has developed into a larger research effort, where researchers have been analyzing long-term monitoring data; measuring individual growth and health to identify critical periods of mortality in delta smelt's annual life cycle, and evaluating the relative contributions of stressors impacting smelt using stage-structured population models (Bennett et al. 2006).

The findings of IEP's monitoring activities have enabled IEP to develop an initial conceptual model hypothesizing that there are at least three factors that, individually or collectively, have lowered pelagic productivity: toxic effects (i.e. pesticides), exotic species effects (including food web impacts), and water project effects (including entrainment).

One “misguided assumption” associated with delta smelt is the emphasis the CALFED program placed on the importance of “shallow water habitat”, generally, for delta smelt. When the CALFED Record of Decision was certified in 2000, restoration of “shallow water habitat” was a desired outcome of program implementation. More recently, it is agreed that “shallow water habitat” is not a useful term unless used in the context of a particular organism or life stage; identification of specific habitat type (i.e. tidal marsh) is more meaningful. The CALFED program’s biggest mistake with respect to restoration of shallow water habitat was an under-appreciation of the role of introduced species. For example, the introduced water weed *Egeria densa* has colonized much of the Delta’s water surface area, providing habitat for predatory fish such as bluegill, striped bass, and sunfish (Brown et al. 2007).

Researchers have observed a trend over the last ten years of declining size and viability in delta smelt; there is speculation that this trend may be a result of high-flow pumping near Tracy in late winter and early spring, coinciding with the period when the largest and most fit Delta smelt spawn. While the pumps do not necessarily take the larger smelt, they can entrain those larvae that are offspring of those early spawning, larger delta smelt. This could have implications in the future on how water operations might be managed to avoid further impacts to the severely diminished delta smelt population (CALFED 2007).

The stage-structured population models employed by researchers at U.C. Davis suggest that delta smelt population growth rates are influenced most by factors operating between juvenile and pre-adult life stages, or during the summer months, relative to other life stages or seasons. The researchers identify growth-associated recruitment failure as the most likely process limiting the delta smelt population, and suggest that restoration actions target summertime habitat conditions despite the likelihood of smelt entrainment in export diversions or exposure to chemical pollutants during that time (Bennett et al. 2006).

The delta smelt population persists by maximizing growth, survival, and reproductive success on an annual basis (a small proportion of delta smelt lives for two years, and despite being highly fecund they are so few in number that their reproductive contribution may only be significant after several years of poor spawning success and survival). Variability in spawning success and larval survival is induced by natural and anthropogenic factors that operate between winter and mid-summer. Spawning success appears to be timed to lunar periods within a water temperature range of about 15-20’C, with longer spawning seasons in cooler years producing more cohorts and higher numbers of adult smelt. Density dependence in late summer, when juvenile abundance is high relative to habitat carrying capacity, may limit the number of juvenile smelt surviving to the adult stage. The carrying capacity is defined by factors that include a decrease in suitable habitat, in combination with a high density of competing planktivorous fishes in late summer and fall (Bennett 2005).

Project Summary Table

Table 1. Delta Smelt project summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-98-C02 ERP-00-B03 ERP-02-P31	**Delta Smelt Culture and Research Program** These projects provided funding for the on-going Delta smelt Culture Project, to develop methods for the successful culture of Delta smelt and provide a reliable supply of all life stages to researchers.	10/01/1999 10/31/2003 10/31/2005	$194,870 $811,380 $400,000 [$1,406,250]	Complete. Several journal articles and a manual published. Final report completed March 2006.
ERP-99-N02	**Fish Treadmill Developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes** This project evaluated performance and behavior of certain fish species exposed to controlled multi-vector flows near a fish screen and suggested refinements for present fish screen design, flow, and operational criteria.	3/31/2002	$1,069,750	Complete. Final report completed October 2001.
ERP-97-C06	**Role of Contaminants in the Decline of Delta smelt in the Sacramento-San Joaquin Estuary** This project evaluated the effects of contaminant exposure on Delta smelt populations.	6/30/2001	$437,326	Complete. Journal articles published in 2005 and 2006.

Other Programs Contributing to ERP Vision

Several programs are underway to restore Delta smelt:

- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes (USFWS) identifies recovery actions for Delta smelt (as well as seven other target species).
- The Central Valley Project Improvement Act (CVPIA) will implement actions benefiting Delta smelt, including changing the timing of diversions, restoring habitat, and dedicating flow during critical periods.
- ESA requirements (biological opinions and habitat conservation plans) will ensure maintenance of existing habitat conditions and implementation of recovery actions.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary, which includes provisions to limit entrainment in diversions and protect habitat conditions for Delta smelt and other species (CALFED 2000).

Much of what is known about delta smelt is generated through the monitoring activities conducted by the IEP. One of the primary purposes of the IEP is to monitor baseline conditions and to assess the ecological impacts of SWP and CVP operations, in accordance with the projects' water right permits, but IEP also conducts special studies to increase understanding of ecological processes and species life histories in the Bay and Delta. As a result of the listing of several native fish as Threatened or Endangered in the 1990s, IEP began putting greater emphasis on listed species in particular, and native species in general; this included adding several new surveys targeting delta smelt (California Resources Agency 2005). All of the data IEP collects is used in water operations management to minimize impacts to the species, and has been a key component in managing the Environmental Water Account (EWA) established as part of the CALFED Record of Decision in 2000.

IEP has also invested considerable effort over the last couple of years in improving the collection, handling, transport, and release (CHTR process) of fish that are entrained in the SWP and CVP export facilities (IEP Annual Conference 2007).

Finally, it is important to note that the CALFED Science Program has provided funding for numerous contracts for researchers to study delta smelt and other aquatic species of concern in 2003 through 2006. Most of these projects are either in their very early stages, or have not yet begun due to contracting delays. It is expected that results from these studies will be incorporated into future restoration actions related to these species, as more information becomes available.

Status of Topic Today

The delta smelt has been listed as Threatened under both the State and federal Endangered Species Acts since 1993. Although environmental groups have recently appealed to the U.S. Fish and Wildlife Service to list the delta smelt federally as Endangered, the delta smelt's Threatened status has not been changed since the CALFED EIR/EIS Record of Decision was certified in 2000 (California Department of Fish and Game 2006).

The delta smelt, along with other pelagic fishes in the Delta, has been experiencing a sustained population decline, despite several wet years and corresponding conditions that should have reversed the population decline observed in the drought period of the late 1980s and early 1990s. The IEP, which monitors the abundance of estuarine fish species in the Bay and Delta, reports that abundance indices from 2002 to 2004 include record low levels of delta smelt and young-of-year striped bass, and near-record low levels of longfin smelt and threadfin shad, whereas the populations of marine and lower estuary species (including salmon) have increased to levels not seen in the past several decades. IEP monitoring has also demonstrated declining levels of zooplankton, such as copepods, that are the primary food of larval pelagic fish and older life stages of delta smelt. The findings of IEP's monitoring activities have enabled IEP to develop an initial conceptual model hypothesizing that there are at least three factors that, individually or collectively, have lowered pelagic productivity: toxic effects (i.e. pesticides), exotic species effects (including food web impacts), and water project effects (including entrainment) (California Resources Agency 2007).

Planned Projects For Implementation

The researchers at U.C. Davis noted that the delta smelt they cultured in the lab have been provided to over 11 different research projects (including toxicological studies), with ongoing requests for cultured smelt from the research community. Given the recent decline in the population of delta smelt (along with other pelagic fish species) in the Delta, researchers attempting to refine their hypotheses on the impacts toxics, exotic species (food web), and water exports have on the delta smelt population will encounter more difficulty in getting “take” permits for wild delta smelt to conduct their studies. Continuation of the delta smelt culture program would make it easier for these important research projects to move forward.

It is suggested that critical data gaps in Delta smelt life history, habitat requirements, and limiting factors be filled through a comprehensive program of research in several key research areas:

- Monitoring and abundance –continue developing statistical estimates based on raw catch and effort records, while integrating new technologies to develop mark-recapture or hydroacoustic protocols.
- Life history – spawning areas and microhabitats, size-specific fecundity, and within-season reproductive strategies.
- Effective population size – understanding risk of extinction based on genetic diversity considerations.
- Growth and mortality – estimates of stage-specific growth and mortality.
- Density dependence and carrying capacity – identification of the underlying mechanisms.
- Interactions with exotic species – mechanisms by which exotic species interfere with delta smelt recruitment.
- Toxic chemicals (pesticides) – use biomarkers as screening techniques to identify effects on individual fish caught during routine monitoring.
- Water project operations – we have limited knowledge of the numbers of larvae lost in exported water and impacts of predators near export facilities; need better understanding of local hydrodynamics and fish distribution over tidal time scales at key locations near the facilities, ultimately evaluated with other known sources of mortality in population models (Bennett 2005).

Impediments to Implementation

ERP funding for the delta smelt culture program ended on October 31, 2005. According to the U.C. Davis researchers, now that they have been successful at working with the more difficult life stages of delta smelt (eggs and larvae), the program's only bottleneck is the lack of funding to continue the culture program (Castillo 2006).

Given limited resources, efforts to protect and then recover delta smelt need to focus on those things believed to be causing the species' population decline. Information from IEP's monitoring activities has enabled IEP to develop an initial conceptual model hypothesizing that there are at least three factors that, individually or collectively, have lowered pelagic productivity: toxic effects (i.e. pesticides), exotic species effects (including food web impacts), and water project effects (including entrainment). The first two factors, toxic effects and exotic species, are particularly difficult to address, as they deal with the extremely difficult situations of assigning responsibility for nonpoint source pollution and the eradication of undesirable exotic species, respectively. Because responsibility for these two factors cannot be assigned to specific entities, non-public funding sources are unlikely to be willingly made available to address these factors. The IEP is developing a final draft of its "Pelagic Organism Decline Synthesis Report" to be released by December 2008; this report will delve further into these three potential causes of the decline in delta smelt and other pelagic organisms, and will offer recommendations on coordination and funding actions to address these factors.

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6. FISH, WILDLIFE AND PLANT SPECIES

6.2 Chinook Salmon

Introduction

Chinook salmon is a MSCS "Recovery" species. Chinook salmon spawn in freshwater, migrate to the ocean as juveniles, and return to freshwater at varying degrees of sexual maturity. There are four runs of Chinook salmon in the Central Valley, distinguished by when they re-enter freshwater: winter, spring, fall, and late-fall. Winter-run Chinook salmon were formally listed as an endangered species under the California Endangered Species Act (CESA) in 1989, and as endangered under the federal Endangered Species Act (ESA) in 1994. Spring-run were listed as a threatened species under CESA in 1998 and ESA in 1999. The National Marine Fisheries Service (NMFS) has reviewed the status of the Central Valley fall-run and late-fall run Chinook salmon ESUs and determined that listing is not warranted at this time, but will continue to consider it a candidate for listing under the ESA. NMFS is expected to have completed draft Recovery Plans for all California recovery domains, including Winter-run and Spring-run Chinook salmon, by early summer 2008.

The key to maintaining and improving Chinook salmon populations will be improving streamflow magnitude, timing, and duration; reducing the effects of the CVP/SWP export pumps in the southern Delta which alter Delta hydrodynamics, juvenile rearing and migration patterns, and cause entrainment at the facilities; and reducing stressors such as unscreened water diversions, high water temperatures, and harvest of naturally spawned salmon.

Because of their life cycle, Central Valley Chinook salmon require high-quality habitats for migration, holding, spawning, egg incubation, emergence, rearing, and emigration to the ocean. These diverse habitats are still present throughout the Central Valley and are maintained to varying degrees by existing ecological processes, but anthropogenic stressors have diminished their quality and accessibility for Chinook salmon. These habitats can be restored through a comprehensive program that strives to restore or reactivate ecological processes, functions, and habitat elements throughout the system. The restoration approach must fully consider the problems and opportunities within each individual watershed and must be fine-tuned to meet the requirements of locally adapted stocks (CALFED 2000).

Applicable ERP Vision

The vision for Central Valley Chinook salmon is to recover all stocks presently listed or proposed for listing under the ESA and CESA; and achieve naturally spawning population levels that support and maintain ocean commercial and ocean and inland recreational fisheries, and that fully use existing and restored habitats (CALFED 2000).

Stage 1 Expectations

The expectations for Stage 1, unique to the various runs of Chinook salmon, were:

- *Winter-run*: The cohort replacement rate (the number of future spawners produced by each spawner) in seven to ten years should continue to exceed 1.7 (as it has in recent years), and average abundance should increase. Battle Creek restoration should have proceeded to a point where the benefits of re-introducing winter-run Chinook can be determined. The determination will be based on genetic considerations. The probability of extinction of winter-run Chinook will have been recalculated using assumptions regarding the establishment of an additional self-sustaining winter-run Chinook population.
- *Spring-run*: Better methods for estimating population sizes should be developed. Populations in Deer, Mill, and Butte creeks should not fall below numbers found in the streams in 1990-1998, with a cohort replacement rate greater than one. Factors limiting survival of out-migrating smolts should be determined. The ability of Big Chico Creek to sustain a spring-run Chinook population should be evaluated and measures taken to improve its capacity to support salmon. The potential for other streams, including Battle Creek, to support runs of spring-run Chinook salmon should be evaluated. The potential for using artificial propagation as a tool to expedite reintroduction to former habitat will have been evaluated and, if deemed appropriate by the resource agencies, a propagation program should be implemented.
- *Fall-run*: Numbers of wild fall-run Chinook salmon should not fall lower than they were in the 1990s. Factors limiting their abundance in each major river should be determined, including the impact of hatchery fish. Programs (e.g. mass marking of hatchery juveniles) should be instituted to allow hatchery fish to be distinguished from wild fish, and surveys should be made to determine the contribution of hatchery fish to natural spawning.
- *Late-fall-run*: Numbers should not fall lower than they were in the 1990s. Methods to determine their abundance should be developed, and factors limiting their abundance should be determined.

Comprehensive Monitoring Assessment and Research Program (CMARP)

In addition to the visions and targets within the ERPP, the CMARP technical appendix identified some possible implementation actions specific to Chinook salmon, including marking hatchery salmon and identifying factors affecting salmon. A constant fractional marking program of salmon smolts released from Central Valley Chinook hatcheries was designed to evaluate hatchery contributions to spawning escapement and ocean and inland recreational fisheries. The goal was to have the program implemented by fall of 2000. In addition, the IEP's Central Valley Salmonid Project Work Team and its satellite teams were to develop proposals to refine understanding of factors affecting survival of juvenile Chinook salmon living in and traveling through the Delta. See Chapter 5.9, Fish and Wildlife Harvest, for additional information on these programs.

Changes Attributable to ERP

The ERP addresses the restoration of natural processes (e.g. adequate instream flows and temperatures), restoration of habitats, and elimination of stressors, which are covered in other chapters of this report. It is important to note that these actions speak to the causes, rather than just the symptoms, of Chinook salmon population declines in the Central Valley, and thus should continue to be the focus of restoration efforts.

Artificial propagation programs, while useful in providing a bank of genetic material and culturing various life stages of Chinook salmon, also run the risk of contributing to the further decline of natural populations through loss of genetic integrity. In the case of natural populations, supplementation through artificial propagation is only appropriate when there is an immediate risk of extinction to the population, or when propagated individuals will be used to populate vacant habitat that is unlikely to be re-colonized naturally within a reasonable timeframe (Arkush and Siri 2001).

The ERP has funded several important projects that cumulatively work together to protect existing populations of Chinook salmon, via captive breeding programs that are defined by rules of conservation biology with an emphasis on genetic conservation:

- *Butte Creek, Big Chico Creek, and Sutter Bypass Chinook Salmon and Steelhead Evaluation / Butte Creek Spring-run Chinook Life History Investigation* (**ERP-01-N49** and **ERP-04-S10**)
- *Molecular Genetic Identification of Chinook Salmon Focused on Spring-run Integrity* (**ERP-95-M08**)
- *Molecular Genetic Identification of Chinook Salmon Focused on Spring-run Integrity* (**ERP-96-M11**)
- *San Joaquin River Drainage Fall-run Chinook Salmon Genetic Baseline and Discrimination Evaluation* (**ERP-97-C09**)

- *Adult Fall-Run Chinook Salmon Movement in the Lower San Joaquin River and South Delta* (**ERP-98-C11**)
- *Health Monitoring of Hatchery and Natural Fall-run Chinook Salmon in San Joaquin River* (**ERP-99-B19**)
- *Genetic Comparison of Stocks Considered for Re-establishing Steelhead in Clear Creek* (**ERP-98-C12**)

For example, the Sacramento River Winter-Run Chinook Salmon Captive Broodstock program, which received funding under *Molecular Genetic Identification of Chinook Salmon Focused on Spring-run Integrity* (**ERP-95-M08**) and *Molecular Genetic Identification of Chinook Salmon Focused on Spring-run Integrity* (**ERP-96-M11**), has utilized genetic information developed under *San Joaquin River Drainage Fall-run Chinook Salmon Genetic Baseline and Discrimination Evaluation* (**ERP-97-C09**), *Butte Creek, Big Chico Creek, and Sutter Bypass Chinook Salmon and Steelhead Evaluation / Butte Creek Spring-run Chinook Life History Investigation* (**ERP-01-N49** and **ERP-04-S10**) to improve hatchery practices to enhance the stock of winter-run Chinook.

San Joaquin River Drainage Fall-run Chinook Salmon Genetic Baseline and Discrimination Evaluation (**ERP-97-C09**) collected genetic data on fall-run Chinook. *Butte Creek, Big Chico Creek,* and *Sutter Bypass Chinook Salmon and Steelhead Evaluation / Butte Creek Spring-run Chinook Life History Investigation* (**ERP-01-N49** and **ERP-04-S10**) have also contributed substantially to genetic research for spring-run Chinook. Analysis of microsatellite DNA variation has revealed five distinct subpopulations which, with the exception of the discovery of two distinct lineages of spring-run Chinook (Butte Creek spring-run, and Deer and Mill Creeks spring-run), match up with the winter-, spring-, fall-, and late-fall-runs that have been identified (Banks et al. 2000).

Finally, in accordance with recommendations contained in the CMARP document, a constant fractional marking program of smolts released from Central Valley Chinook salmon hatcheries was initiated in 2007 (Schroyer 2007).

One study, *Inventory of Rearing Habitat for Juvenile Salmon in the North Delta* (**ERP-96-M27**), found that despite the geographic proximity of two sampling sites (Cache and Miner Sloughs), and the expectation that the two sites would be similar in terms of their availability to juvenile fish in the area, the Miner Slough site was somewhat more accessible from the Sacramento River. While the researcher speculates that the higher capture of certain fish species at one of the sites could have been explained by important differences in the habitat values of the two sites, she admits that it could also be attributable to the limitations of sampling methodologies (specifically, fish at Miner Slough were more susceptible to being captured by seine net because Miner Slough is a much smaller channel with less open water area, allowing more of the channel to be sampled) (Harris 1999). However, this would not explain the significant difference in size between splittail caught at the two sites (splittail from Miner Slough were larger than those from Cache Slough).

As part of the same study, the researcher found that several introduced fish species were found exclusively at the Cache Slough site, and speculated that this could be because the habitat conditions at Cache Slough were more favorable to introduced species than habitat at the Miner Slough site, but stated that further study is required to determine whether these conditions change from year to year, and whether Cache Slough habitat conditions need more time to fully "develop" following earlier restoration efforts (Harris 1999).

One commonly held view, with respect to the genetic diversity of the different runs of Chinook salmon, is that most spring-run populations have hybridized with fall-run, and that spring-run in Butte Creek, in particular, have hybridized with the fall hatchery stock in the Feather River. However, the genetic evaluation of Butte Creek spring-run (*Molecular Genetic Identification of Chinook salmon Focused on Spring-run Integrity* (**ERP-95-M08**)) found that this subpopulation is less genetically akin to the fall-run than it is to spring-run in Deer and Mill Creeks. Even though coded-wire tag returns have supported the idea that the Feather River Hatchery has been hybridizing spring and fall runs, researchers have observed no evidence of past hybridization with respect to linkage disequilibrium or failure of random-mating equilibrium. In fact, despite the concern for the irreversible loss of genetic heterogeneity due to various stressors, researchers are impressed with the substantial genetic diversity and structure they have found among Central Valley Chinook populations (Banks et al. 2000).

Another study, *Health Monitoring of Hatchery and Natural Fall-run Chinook salmon in San Joaquin River* (**ERP-99-B19**), was designed to examine spatial and temporal differences in the health of out-migrating fall-run Chinook from the San Joaquin River. With respect to energy reserves of hatchery vs. natural fish, higher lipid levels were expected to occur in hatchery fish due to their high-energy diets, but researchers found higher condition levels in natural fish, and it was unclear to them whether this extra weight was muscle mass, water, or some other constituent. Such a trend may indicate that growth strategies (lipid deposition vs. muscle mass growth) differ between hatchery and natural fish, and warrants further investigation (Nichols et al. 2001).

New data and techniques, developed under the aforementioned ERP-funded genetic studies, and hatchery management projects that utilize the data from those studies, have changed the thinking on conventional hatchery practices. By establishing sound captive breeding practices based on rules of conservation biology that create populations able to influence the genetic variation of wild stocks, these efforts have cumulatively made some progress toward protecting existing populations and contributing to species recovery. As these new practices are implemented over time, progress should be made toward meeting the goals and targets identified in the ERP documents as well as those of other restoration programs.

One study, *Inventory of Rearing Habitat for Juvenile Salmon in the North Delta* (**ERP-96-M27**), documented juvenile Chinook salmon use of restored areas in the Cache and Miner Slough areas of the Delta, with interesting results and implications for restoration. This study found that the relative abundance of native fish species was higher at the Miner Slough site than at the Cache Slough site for all species except prickly sculpin – in fact, Chinook salmon and Delta smelt were only collected at the Miner Slough site, and splittail abundance was higher at the Miner Slough site than at the Cache Slough site. Also, the relative abundance of introduced species was higher at the Cache Slough site (mostly due to the presence of threadfin shad). This study also described seasonal patterns of fish species occurrence at the two sites – native species were more abundant in spring and early summer, while introduced species became more abundant in late summer and fall (likely because native species tend to breed earlier in the year than introduced species) (Harris 1999). These findings could help to determine which areas in the northern Delta provide optimal conditions for native juvenile fish and where to focus restoration investments in the future.

It is important to note that the CALFED Science Program has provided funding for numerous contracts for researchers to study Chinook salmon and other aquatic species of concern in 2003 through 2006. Most of these projects are either in their very early stages, or have not yet begun due to contracting delays. As results from these studies become available, the information should be incorporated into future restoration actions related to these species.

Project Summary Table

Table 1. Chinook Salmon Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-N49 ERP-04-S10	**Butte Creek, Big Chico Creek, and Sutter Bypass Chinook Salmon and Steelhead Evaluation / Butte Creek Spring-run Chinook Life History Investigation** This project is filling knowledge gaps in the basic life history of spring-run Chinook salmon and steelhead trout populations in Butte and Big Chico Creeks, to help evaluate the effectiveness of fish restoration projects in these two watersheds. ERP-04-S10 extends funding for this project for an additional three years.	6/30/2006 6/30/2010	$762,132	ERP approved an additional three years of funding for this project in 2005.
ERP-99-N02	**Fish Treadmill Developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes** This project evaluated performance and behavior of certain fish species exposed to controlled multi-vector flows near a fish screen and suggested refinements for present fish screen design, flow, and operational criteria.	3/31/2002	$1,069,750	Complete. Final report completed October 2001.
ERP-99-B19	**Health Monitoring of Hatchery and Natural Fall-run Chinook Salmon in San Joaquin River** This project characterized the health and physiological condition of both natural and hatchery juvenile Chinook in the San Joaquin River and Delta.	Final report submitted 1/29/2001	$37,860	Complete. Final report completed January 2001.
ERP-98-C11	**Adult Fall-Run Chinook Salmon Movement in the Lower San Joaquin River and South Delta** This project monitored movement of tagged adult salmon in the lower Delta and San Joaquin River, and evaluated movement against water quality information to assess the relationship of DO levels and operation of barriers in the South Delta.	5/31/2001	$285,000	Complete. Final report drafted for DFG review.
ERP-98-B15	**Evaluation of Increased Tagging Levels for Chinook Salmon and Steelhead and a Demonstration Project on Mass Marking** This project evaluated current tagging practices and demonstrated a technique for the mass marking of hatchery produced salmon, to support subsequent evaluation of harvest practices.	6/30/2002	$616,190	Complete. Final report completed February 2000.
ERP-97-C09	**San Joaquin River Drainage Fall-run Chinook Salmon Genetic Baseline and Discrimination Evaluation** This project developed a genetic baseline for fall run Chinook salmon in the San Joaquin River Basin and evaluated the difference between spawning stocks.	6/30/2002	$387,003	Complete. Genetic info from this project utilized with info from other research projects to study relationships among all Chinook populations.
ERP-96-M27	**Inventory of Rearing Habitat for Juvenile Salmon in the North Delta** This project is an inventory of rearing habitat for juvenile Chinook salmon and other native fishes in the northern Sacramento-San Joaquin Delta (Cache and Miner Sloughs).	9/30/1998	$24,500	Complete. Final report completed August 1999.

Table 1. Chinook Salmon Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-95-M08 ERP-96-M11	**Molecular Genetic Identification of Chinook Salmon Focused on Spring-run Integrity** This project developed molecular and statistical tools for stock discrimination among Central Valley Chinook salmon.	10/31/2000 6/30/2000	$598,086 $750,000 [$1,348,086]	Complete. Numerous journal articles published in 1998-2000.

Other Programs Contributing to ERP Vision

There are three major programs to restore Chinook salmon populations in the Central Valley:

- The Secretary of the Interior was required by the Central Valley Project Improvement Act (CVPIA) to double the natural production of Central Valley anadromous fish stocks by 2002. CVPIA funded a project, *Health Monitoring of Hatchery and Natural Fall-run Chinook Juveniles* (CVPIA-01-F10), documenting the health and physiological condition of hatchery juvenile Chinook from the Merced River Fish Facility and natural juvenile Chinook from the Merced, Tuolumne, and Stanislaus rivers during spring 2001. The project was completed and a final report submitted in November 2002.

- The NMFS is required under the federal ESA to develop and implement a recovery plan for the endangered Winter-run and threatened Spring-run Chinook salmon and to restore these stocks to levels that will allow their removal from the list of endangered species. NMFS is expected to have completed Recovery Plans for all California recovery domains, including Winter-run and Spring-run Chinook salmon, by early summer 2008.

- The California Department of Fish and Game is required under the State's Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988 to double the numbers of salmon that were present in the Central Valley in 1988.

In addition, CESA can provide specific criteria for down-listing, delisting, and recovery of listed species.

It is important to note that the CALFED Science Program has provided funding for numerous contracts for researchers to study Delta smelt and other aquatic species of concern in 2003 through 2006. Most of these projects are either in their very early stages, or have not yet begun due to contracting delays. It is expected that results from these studies will be incorporated into future restoration actions related to these species, as more information becomes available.

Finally, there is a substantial body of Chinook salmon research occurring in upstream watersheds (e.g. Klamath, Trinity, and Russian Rivers, among others); information from these studies, including maps, data tables, charts, and bibliographic resources, is compiled on the Klamath Resource Information System (KRIS) website (www.krisweb.com).

Status of Topic Today

Although NMFS has completed comprehensive status reviews for both winter- and spring-run Chinook salmon, changing both effective ESA listing dates to August 2005, the status of both of these runs has not been changed since the CALFED EIR/EIS Record of Decision was certified in 2000. Fall and late-fall runs remain candidate species for listing under ESA (California Department of Fish and Game 2006).

NMFS is expected to have completed draft Recovery Plans for all California recovery domains, including Winter-run and Spring-run Chinook salmon, by early summer 2008.

Planned Projects For Implementation

The ERP addressed the restoration of natural processes (e.g. adequate instream flows and temperatures), restoration of habitats, and elimination of stressors, which are covered in other chapters of this report. It is important to note that these actions speak to the causes, rather than just the symptoms, of Chinook salmon population declines in the Central Valley, and thus should continue to be the focus of restoration efforts in the future.

Impediments to Implementation

There are several hundred approved recovery plans for U.S. endangered and threatened wildlife, and a majority (more than 60%) of these recommend captive breeding. Given the limited resources available for conservation and recovery measures, and the high costs associated with collecting the required genetic information and incorporating management practices that maximize utilization of that genetic information to protect the species, it is likely that only a few stocks can be identified for such interventions (Arkush and Siri 2001).

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6. FISH, WILDLIFE AND PLANT SPECIES

6.3 Steelhead

Introduction

Steelhead trout (*Oncorhynchus mykiss*) is a MSCS "Recovery" species and is listed as threatened under the ESA. Steelhead trout is an anadromous form of rainbow trout that spawns in freshwater, and its juveniles rear in cool water for a year or more before migrating to the ocean. They spend one to three years in the ocean before maturing and returning to freshwater to spawn. While they rear in fresh water, young steelhead are susceptible to mortality resulting from elevated water temperatures and a variety of other adverse environmental and habitat factors, many of which also affect Chinook salmon.

Historically, steelhead ranged throughout the Sacramento River system (including both east- and west-side tributaries) and the San Joaquin River system. At present, naturally spawning populations of steelhead are known to occur in the upper Sacramento River and tributaries, Mill, Deer, and Butte creeks; and the Feather, Yuba, American, and Stanislaus rivers. However, the presence of naturally spawning steelhead populations appears to correlate well with the locations of programs to monitor for them. Recently implemented monitoring programs have found steelhead in streams previously thought not to contain them, such as Auburn Ravine, Dry Creek, and the Stanislaus River. It is therefore possible that naturally spawning populations exist in many other streams but are undetected due to lack of monitoring or research programs (CALFED 2000).

The National Marine Fisheries Service (NMFS) has identified steelhead populations in the Central Valley as composing a single evolutionarily significant unit (ESU). The Central Valley steelhead ESU comprises the Sacramento River and its tributaries, and the San Joaquin River and its tributaries, downstream of the confluence with the Merced River (including the Merced River). Data from genetic studies show that samples of steelhead from Deer and Mill creeks, the Stanislaus River, Coleman National Fish Hatchery on Battle Creek, and Feather River Hatchery are well differentiated from all other samples of steelhead from California (CALFED 2000). NMFS is expected to have completed draft Recovery Plans for all California recovery domains, including Central Valley Steelhead, by early summer 2008.

Applicable ERP Vision

The vision for Central Valley steelhead trout is to recover this species and achieve naturally spawning populations of sufficient size to support inland recreational fishing and that fully use existing and restored habitat areas (CALFED 2000).

The strategic objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay, and Suisun Marsh. Long and short-term objectives for steelhead are, respectively, to restore self-sustaining populations of steelhead in all streams that historically supported steelhead populations and that contain suitable habitat or that could contain suitable habitat with the implementation of reasonable restoration and protection measures, to determine the abundance, distribution, and structure of existing steelhead populations and to, develop and implement restoration measures and protections that have a relatively high degree of certainty of increasing the number and size of naturally spawning populations.

Stage 1 Expectations

The expectations for Stage 1 were that steelhead numbers should not fall lower than they have been in the 1990s; ongoing efforts to provide passage at impassable dams on key tributaries such as Battle, Clear, and Butte creeks should be accelerated; water operations should provide temperatures adequate for summer rearing in reaches below the major reservoirs; information on the status of natural stocks should be obtained; and adult spawner escapement on all major tributaries should monitored. The following actions were recommended:

- Implement a coordinated approach to restore ecosystem processes and functions, including restoring access to historical habitat presently blocked by dams.
- Implement measures to restore habitat when restoration of ecosystem processes and functions is not feasible. This includes providing adequate flows and water temperatures in tailwater habitats below the major reservoirs.
- Protect spawning and rearing habitat in upper tributary watersheds.
- Improve riparian corridors in lower tributaries and rivers.
- Improve estuary habitat.
- Manage and operate the four hatcheries in the Central Valley that propagate steelhead in order to protect the genetic diversity of naturally and hatchery produced stocks and to minimize ecological impacts of hatchery releases on natural populations.
- Provide sufficient flows in lower tributaries for immigration and emigration to improve migration success.
- Reduce losses to unscreened diversions.

- Increase the scope of catch-and-release recreational fisheries for naturally produced steelhead (the California Fish and Game Commission has adopted more stringent angling regulations for the Central Valley, including not allowing the retention of unmarked [wild] steelhead except in a limited area in the upper Sacramento River).
- Implement programmatic actions proposed in the 14 ecological management zone visions to help achieve steelhead targets by creating and sustaining improved habitat conditions and reducing sources of mortality.

The CMARP technical appendix noted that steelhead have received relatively little study compared to Chinook salmon. It has been assumed that steelhead respond to environmental stresses in the same way as Chinook salmon. The conceptual models prepared by the Chinook salmon teams apply generally to steelhead because the species share an anadromous life history, but there are some significant differences, especially in population structure and dynamics. Most importantly, some stressors common to the two species (particularly those dealing with flow and temperature), have a greater negative impact on steelhead because of the longer period of freshwater rearing by juveniles. The primary stressor identified for steelhead was significant loss of spawning and rearing habitat. It was recommended that the status of steelhead populations and their response to CALFED actions be monitored because it is federally listed as “Threatened” and it supports a valuable recreational fishery (CALFED 2000).

Six major knowledge gaps that require new monitoring and assessment programs or enhancements to ongoing anadromous fish monitoring programs were identified:

- Current distribution and abundance of naturally-spawning populations.
- Specific spawning and rearing habitat requirements and assessment of existing habitat.
- Genetic and population structure of Central Valley steelhead.
- Feasibility of providing access and restoration of potential habitat currently above impassable dams.
- The degree of straying of hatchery steelhead and the effects of straying on naturally-spawning populations. Assessing these effects may require documentation of straying in natural populations as well.
- Effects of water project operations in the delta/estuary (CALFED 2000).

Specific recommendations for habitat and population monitoring specific to Central Valley steelhead, included:

- Habitat typing and mapping.
- Stream flow and temperature monitoring.
- Identification of other stressors important in specific situations (e.g. sedimentation).

- Population monitoring for several life stages, including spawning adults, rearing juveniles, and emigrating juveniles (CALFED 2000).

Changes Attributable to ERP

There are several related but non-ERP-funded studies which suggest that steelhead distribution can be inferred from Chinook salmon distribution; in nearly all cases, steelhead were present at higher elevations in the streams than Chinook salmon. It is believed that steelhead were therefore more extensively distributed than Chinook salmon in the Central Valley, largely due to their superior jumping ability, their upstream migration during the winter rainy season, and their less restrictive preference for spawning substrates (McEwan 2001).

Most of the ERP actions speak directly to the restoration of natural processes (e.g. adequate instream flows and temperatures), restoration of habitats, and elimination of stressors, which are covered in other chapters of this report. It is important to note that these actions speak to the causes, rather than just the symptoms, of Central Valley steelhead population declines, and thus should continue to be the focus of restoration efforts.

Results of genetic analyses funded by the ERP (under *Genetic Comparison of Stocks Considered for Re-establishing Steelhead in Clear Creek* (**ERP-98-C12**) and *Central Valley Steelhead Genetic Evaluation* (**ERP-99-N12**) found that significant steelhead genetic population structure exists throughout the Central Valley. While there is lack of genetic divergence between steelhead from the Sacramento and San Joaquin River systems, suggesting a common ancestry, there is a relatively high level of population structuring within individual rivers of each system. This genetic diversity and population structuring should be considered carefully in future conservation or restoration activities (Nielsen et al. 2003).

Populations from the Coleman, Nimbus, and Feather River fish hatcheries were similar in genetic diversity to geographically proximate populations; this may indicate gene flow among populations, or a common ancestry and local origins of the hatchery stock. However, genetic analyses of steelhead on the American, Stanislaus, Tuolumne, and Yuba rivers were more difficult to interpret, as there was more genetic separation between trout populations above and below dams on these rivers. Additional study may allow us to infer the direction and duration of isolation between populations above and below barriers on these rivers, and determine whether native stocks of steelhead remain isolated above these dams or whether the genetic difference is due to the influence of rainbow trout stocked above the dams (Nielsen et al. 2003).

Trout sampled in Upper Clear Creek (above and below Bear Creek) had significantly greater genetic differences than fish collected below McCormick-Saeltzer Dam on Clear

Creek. Upper Clear Creek trout were also significantly different from trout collected in Deer and Mill Creeks, suggesting that the presumed anadromous origins of populations in upper Clear Creek deserve further investigation (Nielsen et al. 2003).

It has been assumed that steelhead respond to environmental stresses in the same way as Chinook salmon, because they share an anadromous life history; restoration actions under CVPIA and CALFED are mostly directed at Chinook salmon recovery with relatively little emphasis on specific actions for steelhead recovery. Most importantly, there are differences in the severity of impacts of stressors common to the two species (particularly those dealing with flow and temperature), which can be greater for steelhead because of the longer period of freshwater rearing by juveniles (McEwan 2001).

As with Chinook salmon protection efforts, restoration actions that focus only on increasing population numbers and ignore the need to increase population genetic diversity may be inadequate. Significant genetic population structure exists for Central Valley steelhead, and needs to be carefully considered in any future conservation and restoration efforts. For example, Spring Creek trout were sampled as part of a study on Clear Creek; the researcher concluded that the Spring Creek trout population was severely bottlenecked with limited genetic diversity and a low effective population size, and therefore suggested that this population would not be a good candidate for restoration of steelhead populations in Clear Creek (Nielsen et al. 2003).

There is more genetic similarity between “winter-run” and “summer-run” steelhead inhabiting one stream than there is between “winter-run” steelhead inhabiting different streams. This calls for an integrated strategy that does not ignore the importance of non-anadromous rainbow trout in maintaining the diversity of the species. Population recovery can only be addressed through an integrated strategy that treats all life-history forms occupying a stream as a single population. In its ESA listing for steelhead, the federal government needs to include non-anadromous forms of rainbow trout as an important cause of the persistence of anadromous steelhead (McEwan 2001).

It is important to note that the CALFED Science Program has provided funding for numerous contracts for researchers to study steelhead and other aquatic species of concern in 2003 through 2006. Most of these projects are either in their very early stages, or have not yet begun due to contracting delays. It is expected that results from these studies will be incorporated into future restoration actions related to these species, as more information becomes available.

Project Summary Table

Table 1. Steelhead Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-N49 ERP-04-S10	**Butte Creek, Big Chico Creek, and Sutter Bypass Chinook salmon and Steelhead Evaluation / Butte Creek Spring-run Chinook Life History Investigation** This project is filling knowledge gaps in the basic life history of spring-run Chinook salmon and steelhead trout populations in Butte and Big Chico Creeks, to help evaluate the effectiveness of fish restoration projects in these two watersheds. ERP-04-S10 extends funding for this project for an additional three years.	6/30/2006 6/30/2010	$762,132	ERP approved an additional three years of funding for this project in 2005.
ERP-99-N12	**Central Valley Steelhead Genetic Evaluation** This project described the genetic and population structure and genetic variation of Central Valley Steelhead populations, yielding information on relationships among native rainbow trout and steelhead and hatchery steelhead.	12/31/2003	$70,636	Complete. Final report completed April 2004 (included results from related project ERP-98-C12).
ERP-99-N02	**Fish Treadmill Developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes** This project evaluated performance and behavior of certain fish species exposed to controlled multi-vector flows near a fish screen and suggested refinements for present fish screen design, flow, and operational criteria.	3/31/2002	$1,069,750	Complete. Final report completed October 2001.
ERP-98-N03	**Life History and Stock Composition of Steelhead Trout** This project characterized the life history patterns and stock composition of steelhead in the Yuba River to support ecosystem restoration and species recovery programs.	8/31/2006	$120,000	Per quarterly report (10/06), awaiting response from CA Bay-Delta Authority on whether this contract was extended through Aug 2007.
ERP-98-C12	**Genetic Comparison of Stocks Considered for Re-establishing Steelhead in Clear Creek** This project obtained information on the genetic diversity of steelhead/rainbow trout from the Coleman National Fish Hatchery, the mainstem of the Upper Sacramento River, and Mill, Deer, and Clear Creeks, to determine preferred sources of a founding stock for re-establishing a self-sustaining steelhead population in Clear Creek.	9/30/2004	$45,492	Complete. Final report completed April 2004 (included results from related project ERP-99-N12).

Other Programs Contributing to ERP Vision

Several programs are underway to restore steelhead:

- The U.S. Fish and Wildlife Service's goal, as established by the CVPIA, is to double the natural production of Central Valley anadromous fish stocks by 2002.
- The California Department of Fish and Game is required under the State's Salmon, Steelhead Trout and Anadromous Fisheries Program Act of 1988 to attempt to double the numbers of steelhead estimated to have been present in the Central Valley in 1988.
- The National Marine Fisheries Service is required under ESA to develop and implement a recovery plan for the threatened Central Valley steelhead ESU and to restore the stock to levels that would allow for their removal from the list of endangered species.
- In addition, CESA can provide specific criteria for down-listing, delisting, and recovery of listed species (CALFED 2000).

It is important to note that the CALFED Science Program has provided funding for numerous contracts for researchers to study steelhead and other aquatic species of concern in 2003 through 2006. Most of these projects are either in their very early stages, or have not yet begun due to contracting delays. It is expected that results from these studies will be incorporated into future restoration actions related to these species, as more information becomes available.

Finally, there is a substantial body of steelhead research occurring in upstream watersheds (e.g. Klamath, Trinity, and Russian Rivers, among others); information from these studies, including maps, data tables, charts, and bibliographic resources, is compiled on the Klamath Resource Information System (KRIS) website (www.krisweb.com).

Status of Topic Today

Although NMFS has completed comprehensive status reviews for Central Valley ESU steelhead trout, changing its official listing date to February 2006, its "Threatened" status under ESA has not been changed since the CALFED EIR/EIS Record of Decision was certified in 2000. Steelhead are not listed under CESA (California Department of Fish and Game 2006). NMFS is expected to have completed Recovery Plans for all California recovery domains, including Central Valley Steelhead, by early summer 2008.

Planned Projects for Implementation

All of the actions recommended in the ERP document for steelhead address the restoration of natural processes, restoration of habitats or access to habitats and elimination of stressors, which are covered in other chapters of this report. It is important to note that these actions speak to the causes, rather than just the symptoms, of steelhead population declines in the Central Valley, and thus should continue to be the focus of restoration efforts in the future.

Impediments to Implementation

There is inadequate funding for anadromous fish monitoring, which means monitoring programs must be narrowly focused. Because Chinook salmon have a higher societal profile (i.e. are commercially exploited and politically sensitive) than steelhead, Chinook salmon monitoring programs get the bulk of the funding and attention.

References

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Nielsen, J. L., S. Pavey, T. Wiacek, G. K. Sage and I. Williams. 2003. Genetic Analyses of Central Valley Trout Populations, 1999-2003. U.S. Geological Survey, Alaska Science Center. Dec. 2003.

6. FISH, WILDLIFE AND PLANT SPECIES

6.4 Sacramento Splittail

Introduction

Sacramento splittail (*Pogonichthys macrolepidotus*) is a MSCS "Recovery" species. Sacramento splittail are common in the Sacramento-San Joaquin Delta estuary and the lower reaches of the Sacramento and San Joaquin Rivers. They tolerate a wide range of salinity, but are most abundant in shallow areas where salinity is less than 10 parts per thousand (ppt). Spawning occurs in fresh water, primarily in floodplain areas upstream of the Delta, including the Mokelumne, Feather, and American rivers, and downstream of the Delta in the Napa and Petaluma Rivers. Spawning habitat includes shallow edgewaters and seasonally flooded riparian zones and flood bypass areas that provide spawning substrate (e.g. submerged vegetation). Rearing habitat includes shallow, fresh and brackish (less than 10 ppt salinity) water habitat that provides a protective, food-rich environment.

Sacramento splittail have limited productivity, particularly in periods of drought, primarily from low freshwater inflow to the Bay-Delta and modification of habitat by past and ongoing human actions. Dams and levees restrict access to historical, seasonally flooded spawning and rearing habitat. Abundant year classes are generally associated with winter and spring flows sufficient to flood peripheral areas of the Delta and lower river reaches, including the flood bypass system of the Sacramento River and the floodplain of the San Joaquin River. Flood control reservoirs generally reduce flooding in these areas.

The population abundance and year-class abundance of Sacramento splittail vary greatly. Low year-class success occurred throughout the 1987-1992 drought years. Age-0 abundance declined in the estuary during the 6-year drought and typically declines in dry years. Sacramento splittail have a high fecundity which, when combined with years of high flows, allows the population to benefit from high recruitment rates.

Floodplain inundation is a significant element required to maintain strong year classes. Restrictions to the floodplain, loss of marshes, and reduced winter-spring river flows from flood control and water supply development have reduced Sacramento splittail's range and abundance. In addition, water quality problems (e.g. high temperature and dissolved solids) reduce the use of the lower San Joaquin River by Sacramento splittail.

Food availability, toxic substances, and competition and predation (particularly from striped bass and other introduced species) are among other factors limiting Sacramento splittail abundance. In addition, harvest for food and bait by sport anglers may inhibit recovery of the Sacramento splittail population.

Sacramento splittail would benefit from improvements in spawning and rearing habitat, and late winter and spring river flows. Increases in the frequency of floodplain inundation, improved access to floodplain areas, and increased freshwater flows would contribute most to their recovery (CALFED 2000).

Applicable ERP Vision

The vision for Sacramento splittail is to recover this species. This would contribute to the overall species richness and diversity, and to reduce conflict between protection for this species and other beneficial uses of water, in the Bay-Delta (CALFED 2000).

The strategic objective is to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay and Suisun Marsh. Long and short-term objectives are, respectively, to restore the Sacramento splittail so that it is one of the most abundant fish species in the estuary and its tributaries, and to achieve the recovery goals for Sacramento splittail identified in the Delta Native Fisheries Recovery Plan (CALFED 2000).

Stage 1 Expectations

Expectations for Stage 1 were that at least one additional strong year class should have developed to maintain Sacramento splittail populations, while factors limiting their spawning and recruitment success would be determined and accounted for in a management plan. The targets for Sacramento splittail included consistently achieving a fall midwater trawl index of 20 units or higher, and a Suisun Marsh trawl index consistently of four units or higher.

The following actions were recommended:

- Improve late winter and spring freshwater flows.
- Increase flooded and shallow water spawning habitat in rivers and Bay-Delta.
- Reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin.
- Prevent introduction of non-native species.

Changes Attributable to ERP

The ERP addresses the restoration of natural processes (e.g. adequate freshwater flows), restoration of habitats, and elimination of stressors, which are covered in other chapters of this report. It is important to note that these actions speak to the causes, rather than just the symptoms, of Sacramento splittail population declines, and thus should continue to be the focus of restoration efforts.

The ERP funded a contract *Chronic Toxicity of Environmental Contaminants in Sacramento Splittail: A Biomarker Approach* (**ERP-99-N07**) for researchers at U.C. Davis to assess the impact of contaminant exposure on Sacramento splittail collected from the Delta. The researchers detected organochlorine contaminants and trace metals in the tissues of all fish. Histopathology indicated presence of macrophage aggregates in gonads, kidneys, and liver, and high incidence of liver abnormalities (particularly glycogen depletion and lipidosis).

Results from this study did not indicate that exposure to the monitored contaminants caused tissue-level effects to Sacramento splittail, as supported by three lines of evidence: 1) tissue concentrations were generally below residue-based effects thresholds; 2) statistical associations between tissue residues and histopathological effects were weak; and 3) observed statistical associations were more consistent with general nutritional stress or baseline variability within the population (Teh 2006).

These findings do not rule out the possibility of contaminant effects to Sacramento splittail because the study did not monitor a wide range of contaminants that may affect species, and did not evaluate synergistic effects of contaminant exposure in combination with other stressors. These present further research opportunities (Teh 2006).

Project Summary Table

Table 1. Sacramento Splittail Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding ($)	Project Status
ERP-99-N07	**Chronic Toxicity of Environmental Contaminants in Sacramento Splittail: A Biomarker Approach** This project demonstrated the use of biomarkers, in conjunction with ongoing fish biomonitoring efforts and water, sediment, and tissue contaminant monitoring, to evaluate the chronic effects of contaminants on the health of splittail under laboratory and field conditions.	1/30/2006	1,113,724	Complete. Numerous journal articles published 2002-2006. Final report completed March 2006.

Table 1. Sacramento Splittail Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding ($)	Project Status
ERP-99-N02	**Fish Treadmill Developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes** This project evaluated performance and behavior of certain fish species exposed to controlled multi-vector flows near a fish screen and suggested refinements for present fish screen design, flow, and operational criteria.	3/31/2002	1,069,750	Complete. Final report completed October 2001.

Other Programs Contributing to ERP Vision

Several programs are underway to restore Sacramento splittail:

- The Recovery Plan for the Sacramento/San Joaquin Delta Native Fishes will be considered in developing program actions.
- CVPIA will implement actions that will benefit Sacramento splittail, including changing diversion timing, restoring habitat, and dedicating flow during critical periods for co-occurring species.
- The State Water Resources Control Board will implement the Water Quality Control Plan for the San Francisco/Sacramento-San Joaquin Delta estuary, which includes provisions to limit entrainment in diversions and protect habitat for Sacramento splittail and other species (CALFED 2000).

In addition, the CALFED Science Program funded a study on Sacramento splittail genetics *Population Genetics of Splittail* (SCI-03-C17), which found that there are two genetically distinct populations of Sacramento splittail. Fish sampled east of the Delta (Sacramento, Cosumnes, and San Joaquin groups) are genetically similar and comprise the Central Valley population, and are significantly distinct from those collected from the Napa and Petaluma Rivers. The genetic distinction between the two populations appears correlated with salinity differences between migratory regions and spawning grounds. Sacramento splittail from the Petaluma River exhibited a significantly higher degree of differentiation from the Central Valley population than did Napa River splittail. Results of this study suggest that existing monitoring programs are probably highly biased towards sampling Sacramento splittail from the Central Valley population (Baerwald and May 2006, Baerwald et al. 2007).

It is important to note that the CALFED Science Program has provided funding for numerous contracts for researchers to study steelhead and other aquatic species of concern in 2003 through 2006. Most of these projects are either in their very early stages, or have not yet begun due to contracting delays. It is expected that results from these studies will be incorporated into future restoration actions related to these species, as more information becomes available.

Status of Topic Today

At the time the ERPP was adopted as part of the CALFED EIR/EIS in 2000, Sacramento splittail had been listed as threatened under the ESA, and was a candidate for listing under CESA. However, on June 23, 2000, the Federal Eastern District Court of California found the final ESA listing rule to be unlawful, and remanded it back to the USFWS for a reevaluation. After a thorough review, the USFWS removed the Sacramento splittail from the ESA threatened species list on September 22, 2003 (California Department of Fish and Game 2006).

Planned Projects for Implementation

All four Actions identified within the ERPP speak to the restoration of natural processes (e.g. adequate freshwater flows), restoration of habitats, and elimination of stressors, which are covered in other chapters of this report. It is important to note that these actions speak to the causes, rather than just the symptoms, of Sacramento splittail population declines, and thus should continue to be the focus of restoration efforts.

Population Genetics of Splittail (SCI-03-C17) recommended expanding existing monitoring programs to include all splittail populations (rather than just Central Valley populations). This would enable better understanding of splittail population dynamics; information which could be used in future restoration actions for this species (Baerwald et al. 2007).

Impediments to Implementation

There is inadequate funding for fish monitoring in general, which means monitoring programs must be narrowly focused. Because Sacramento splittail do not have as high a societal profile as species like Chinook salmon and delta smelt, monitoring programs geared toward Sacramento splittail get significantly less funding and attention.

References

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Baerwald, M., V. Bien, F. Feyrer and B. May. 2007. Genetic Analysis Reveals Two Distinct Sacramento Splittail (Pogonichthys macrolepidotus) Populations. Draft research article. SCI-03-C07. Feb. 2007.

CALFED Bay-Delta Program. 2000. Comprehensive Monitoring Assessment and Research Program (CMARP). Final Programmatic EIS/EIR Technical Appendix. July 2000.

California Department of Fish and Game. 2006. State and Federally Listed Endangered and Threatened Animals of California. Biogeographic Data Branch. Oct. 2006.

Teh, S. J. 2006. Chronic Toxicity of Environmental Contaminants in Sacramento Splittail (*Pogonichthys macrolepidotus*): A Biomarker Approach. Final project report. ERP-99-N07. Jan. 2006.

6. FISH, WILDLIFE AND PLANT SPECIES

6.5 Green Sturgeon and White Sturgeon

*(**Note:** Due to the life history similarities between green sturgeon and white sturgeon the analysis has been combined into one section.)*

Introduction

Green sturgeon (*Acipenser medirostris*) is a MSCS "Recovery" species. White sturgeon (*Acipenser transmontanus*) is in the MSCS section for "Maintain" and/or "enhance harvested species". Both sturgeon are native to Central Valley rivers and the Bay-Delta and represent an important component of the historic native fish fauna. Throughout recorded history, white sturgeon have been the dominant sturgeon populations in the Bay- Delta system, whereas in smaller systems such as the Eel River, green sturgeon dominate.

Sturgeon rear in the Sacramento-San Joaquin estuary and spawn in the Sacramento and San Joaquin rivers and their major tributaries. Sturgeon may leave the Bay-Delta and move along the coast to as far as Alaska. Populations of green sturgeon are found in many of the larger rivers from California north to British Columbia.

Green sturgeon inhabit both saltwater and fresh water and tolerate a wide range of salinity concentrations. Habitat requirements of green sturgeon are poorly known, but spawning and larval ecology are probably similar to that of the better known white sturgeon. Spawning is thought to occur in larger rivers upstream of the Delta. Low river flow during late winter and spring may reduce attraction of sturgeon to specific rivers and reduce spawning success. Stream channelization and flood control measures on large rivers (e.g. levee construction) may affect sturgeon use and spawning success.

Food availability, toxic substances, and competition and predation are among the factors influencing the abundance of sturgeon. Sturgeon are long lived (e.g. some live over 50 years) and may concentrate pollutants in body tissue from eating contaminated prey over long periods. Harvesting by sport fishers also affects abundance of the adult populations. Illegal harvest (poaching) also reduces the adult population.

Reducing stressors is an important component of restoring white and green sturgeon populations. Reducing losses to diversions from the Sacramento-San Joaquin Delta estuary would increase survival of young sturgeon. Sturgeon would also benefit from actions to reduce pollutant input to streams and rivers in the Sacramento-San Joaquin River basin.

Applicable ERP Vision

The vision for both green and white sturgeon in ERPP Volume 1 is to restore population distribution and abundance to historical levels. In addition, the vision for green sturgeon is to recover the species.

The Strategic Objectives included to achieve, first, recovery and then large self-sustaining populations of at-risk native species dependent on the Delta, Suisun Bay and Suisun Marsh; and to enhance fisheries for salmonids, white sturgeon, Pacific herring, and native cyprinid fishes.

The long-term objective for green sturgeon was to increase the population in order to benefit the recreational fishery. The short-term objective was to continue the efforts established under Stage I Expectations and implement actions based on information about habitat needs.

For white sturgeon, the long term strategic objective was to increase white sturgeon numbers (and harvest) by improving habitat conditions for spawning and rearing throughout the Sacramento-San Joaquin estuary and tributaries. The short-term objective was to continue to manage white sturgeon for the sustainable sport fishery, without artificial propagation.

The rationale for these objectives was that, "The green sturgeon is relatively uncommon in the Bay-Delta system compared to the white sturgeon and probably always has been. However, the population appears to be one of only three still in existence in North America, so it needs special consideration. Very little is known about the requirements of this species in the system, and the recovery goals identified in the Delta Native Fishes Recovery Plan are based on knowledge gained from their incidental catch in white sturgeon studies and fisheries. Thus, restoration and management of this species requires much better knowledge than currently exists. Because it is so long lived (50+ years) and current exploitation levels seem to be low, there is time to conduct systematic research on its biology to determine the best ways to increase its populations."

Stage 1 Expectations

The ERP expectations for Stage 1 were to develop a better understanding about green sturgeon life history and use of the Sacramento-San Joaquin estuary and its watershed for spawning and rearing. In addition, a program will have been implemented to monitor ocean migration and its importance in the life history of the species (CALFED 2000b).

In identifying a species target for green sturgeon, ERPP Volume 1 states, “The recovery goal will be achieved when 1) the median population of mature fish (over 1 meter in length) has reached 1,000 fish, including 500 females over 1.3 meters in total length, over a 50 years period or for 5 generations (CALFED 2000b).”

In addition to the visions and targets within the ERPP, the CMARP technical appendix identifies some possible implementation actions specific to green sturgeon, including recommendations to assess monitoring methods for green sturgeon (including use of fyke nets to capture young-of-the-year green sturgeon at the Red Bluff Diversion Dam on the Sacramento River) and to increase egg and larval sampling in the upper Sacramento River and Feather River. The document also identifies some possible implementation actions specific to white sturgeon, including recommendations to increase tagging efforts for adult white sturgeon and to increase trawling efforts in the lower Sacramento River and Suisun Bay for juvenile white sturgeon (CALFED 2000a).

Changes Attributable to ERP

ERP has funded several studies and monitoring efforts for green sturgeon. *Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watersheds* (**ERP-98-C15, ERP-00-B06, ERP-02D-P57**) provided funding for researchers at U.C. Davis to study various aspects of green sturgeon’s life history, genetics, biological requirements, and reproductive functions in response to stressors, as well as investigation into the feasibility of culturing green sturgeon for further research.

Tagging green sturgeon enabled the U.C. Davis researchers to verify and determine the timing of Sacramento River migration and abundance of sturgeon in spawning locations. Green sturgeon move rapidly through the system once they leave the ocean and initiate migration upriver, covering the distance between Rio Vista and Knight’s Landing in a period of 5-12 days. Researchers found that the reach of the Sacramento River adjacent to the Glenn-Colusa Irrigation District’s pumping plant holds a large aggregation of green sturgeon that are vulnerable to sport angling, and that additional protection of the species should be focused at this reach. Also, the closure of the gates at the Red Bluff Diversion Dam impedes the upstream migration of some late-migrating green sturgeon; it is suggested that delaying the closure of these gates for six weeks would enable those sturgeon to move upstream of the dam and likely spawn there (Klimley 2006).

Juvenile green sturgeon showed a 25% decrease in metabolic scope for activity with chronic stress. The effect of high river temperatures was determined for post yolk-sac larval to early juvenile stages’ growth rates. Elevated temperatures experienced by pre-larvae can lead to significant mortality (28˚C) and deformities (22-28˚C). Juveniles were not adversely affected by temperatures in the 19-24˚C range if they had abundant food and oxygen (juvenile green sturgeon's acute temperatures tolerance was found to be 34.7˚C (Klimley 2006).

Several green sturgeon caught in the lower Klamath River were used for artificial spawning between 1999 and 2005 (spawning procedures followed those developed for white sturgeon). Early spawning trials had less adhesive eggs compared to white sturgeon and low fertilization and hatching rates; the objective was to improve the procedures for hormonal treatment, artificial fertilization, and egg incubation. Induced spawning was improved by reducing broodfish holding time, withdrawing domperidone from the hormonal treatment, and collecting eggs within 1.5 hours of ovulation. Sex differentiation in juveniles occurred at age six months. Males reached full sexual maturity at age four to six years; and produced viable sperm each spring, indicating an annual reproductive cycle. Females are expected to be fully sexually mature at the age of eight years, and their reproductive cycles are predicted to be primarily biennial (the same as domestic white sturgeon stocks). Both males and females mature younger in culture but at a body size similar to early-maturing wild fish (Klimley 2006).

This study also analyzed Sacramento River, Klamath River, and Rogue River collections of green sturgeon to assess the genetic differentiation between them. Their data supports the hypothesis that there are multiple populations of green sturgeon, and those spawned in the Sacramento River are genetically divergent from an independent breeding stock of green sturgeon spawning in the rivers of the Klamath Mountains Province (Klimley 2006).

ERP also funded a contract with U.S. Fish and Wildlife Service *Spawning Areas of Green Sturgeon in the Upper Sacramento River* (**ERP-98-C13**) to investigate green sturgeon spawning activity in the upper Sacramento River and identify specific spawning locations, using artificial substrates and larval nets. They concluded that green sturgeon spawn in the upper Sacramento River, both above and below the Red Bluff Diversion Dam. Temperature ranges in this area are similar to conditions used in the successful artificial rearing of green sturgeon (the U.C. Davis studies referenced above), and therefore do not appear to limit successful spawning of green sturgeon, although suitable habitat upstream of Red Bluff Diversion Dam is inaccessible to sturgeon when the dam gates are lowered.

While habitat requirements of green sturgeon are poorly known, the characteristics of green sturgeon eggs (i.e. large egg size and thin chorionic layer on the egg) indicate that colder (8-14˚C), cleaner water is required for spawning. Spawning substrate immediately below the Red Bluff Diversion Dam, where eggs were collected, is mainly large cobble and above Bend Bridge, where a larva was collected, substrate is a combination of gravel and bedrock. These substrates and temperatures are consistent with expectations at sites where the eggs and larva were found. This study arrived at the same results as the U.C. Davis studies in relation to upstream passage of the Red Bluff Diversion Dam: although green sturgeon spawn below the dam, the size of upstream migrating adult sturgeon precludes their use of existing fish ladders at the Dam and therefore no green sturgeon are able to move upstream once the gates are in place (Brown 2002).

Finally, one contract, *Selenium Effects on Health and Reproduction of White Sturgeon, Acipenser transmontanus, in the Sacramento-San Joaquin Estuary* (**ERP-02-P35**), was funded for U.C. Davis researchers to document the effects of selenium on the health and reproduction of white sturgeon in the Sacramento-San Joaquin estuary. Selenium concentration was significantly higher in kidneys than in the liver, muscle, and gonad (liver had insignificantly elevated selenium concentration over muscle, and gonad tissue exhibited the lowest selenium burden). Selenium concentrations in muscle and liver were positively correlated with the age and size of white sturgeon. Mean selenium in white sturgeon muscle and liver was documented to be close to levels associated with toxicity and reproductive failure in other fish species. Researchers note that several individual fish greatly exceed these thresholds. They also note the high variation in selenium levels of white sturgeon sampled in their study could be linked to different foraging locations within San Francisco Bay or could be due to the effect of seasonality (linked to the seasonal variability of *Potamocorbula amurensis*, the primary source of food selenium for white sturgeon from the area). Researchers observed that microinjection of selenium in white sturgeon larvae significantly increased mortality and abnormality rates (including edema and spinal deformities) in larvae containing over 15 micrograms per gram of selenium (Doroshov 2004).

Project Summary Table

Table 1. Green Sturgeon and White Sturgeon Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-N49 ERP-04-S10	**Butte Creek, Big Chico Creek, and Sutter Bypass Chinook salmon and Steelhead Evaluation / Butte Creek Spring-run Chinook Life History Investigation** This project is filling knowledge gaps in the basic life history of spring-run Chinook salmon and steelhead trout populations in Butte and Big Chico Creeks, to help evaluate the effectiveness of fish restoration projects in these two watersheds. ERP-04-S10 extends funding for this project for an additional three years.	6/30/2006 6/30/2010	$762,132	ERP approved an additional three years of funding for this project in 2005.
ERP-02-P35	**Selenium Effects on Health and Reproduction of White Sturgeon, Acipenser transmontanus, in the Sacramento-San Joaquin Estuary** This project assessed the correlation between Se tissue burden and physiological effect in different life stages of wild white sturgeon, and determined the effects of Se on the development and survival of embryos and yolk sac larvae.	11/30/2004	$150,047	Complete. Final report completed November 2004.
ERP-98-C15 ERP-00-B06 ERP-02D-P57	**Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watersheds** These projects determined baseline information of green sturgeons' biological requirements and the feasibility of its culture, investigated its movement and distribution in the Bay-Delta, and described its habitats with emphasis on spawning sites.	10/31/2001 5/31/2002 1/31/2007	$1,444,2351	Complete. Journal articles published in 2003-2006. Final report completed November 2006.
ERP-99-N02	**Fish Treadmill Developed Fish Screen Criteria for Native Sacramento-San Joaquin Watershed Fishes** This project evaluated performance and behavior of certain fish species exposed to controlled multi-vector flows near a fish screen and suggested refinements for present fish screen design, flow, and operational criteria.	3/31/2002	$1,069,750	Complete. Final report completed October 2001.
ERP-98-C13	**Spawning Areas of Green Sturgeon in the Upper Sacramento River** This project investigated sturgeon spawning activity in the upper Sacramento River and identified specific spawning locations.	1/31/2002	$60,801	Complete. Final report completed January 2002.

Other Programs Contributing to ERP Vision

Several programs are underway to restore sturgeon:

- The Central Valley Project Improvement Act (CVPIA) (PL 102-575) calls for implementing changes in flows and project facilities and operations by 2002 that lead to doubling of the sturgeon populations. CVPIA funded part of the

- The Salmon, Steelhead Trout, and Anadromous Fisheries Program Act of 1988 requires DFG to restore historical numbers of sturgeon in the Central Valley.
- The Four Pumps (SWP) and Tracy (CVP) Fish Agreements provide funds to DFG for sturgeon restoration.
- The Recovery Plan for the Sacramento-San Joaquin Delta Native Fishes (USFWS) identifies recovery actions for green sturgeon.

Status of Topic Today

When the ERPP was adopted as part of the CALFED EIR/EIS Record of Decision in 2000, green sturgeon was designated as a species of special concern by the California Department of Fish and Game and the U.S. Fish and Wildlife Service. While its status has not changed under the CESA, green sturgeon was listed under the ESA as threatened on July 6, 2006 (California Department of Fish and Game 2006).

Planned Projects for Implementation

There should be an effort to increase enforcement presence near the GCID pump, when green sturgeon are present, to protect against overharvest. The feasibility of closing the RBDD gates six weeks later should be investigated, so that late-migrating sturgeon can reach suitable habitat upstream of the Dam.

Impediments to Implementation

The U.S. Fish and Wildlife researchers indicate that funding for their study was limited to one year, but with a multi-year study program, they could evaluate the availability and use of specific spawning sites and estimate baseline habitat needs such as substrate type and water velocity, temperature, and depth.

References

Brown, K. 2002. Spawning Areas of Green Sturgeon, *Acipenser medirostris*, in the Upper Sacramento River, California. Final project report. ERP-98-C13. U.S. Fish and Wildlife Service, Red Bluff Fish and Wildlife Office. Red Bluff, CA.

CALFED Bay-Delta Program. 2000a. Comprehensive Monitoring Assessment and Research Program (CMARP). Final Programmatic EIS/EIR Technical Appendix. July 2000.

CALFED Bay-Delta Program. 2000b. Ecosystem Restoration Program Plan - Volume I: Ecological Attributes of the San Francisco Bay-Delta Watershed. Final Programmatic EIS/EIR Technical Appendix. Sacramento, CA. July 2000.

California Department of Fish and Game. 2006. State and Federally Listed Endangered and Threatened Animals of California. Biogeographic Data Branch. Oct. 2006.

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Klimley, A. P. 2006. Biological Assessment of Green Sturgeon in the Sacramento-San Joaquin Watershed, Phase 5. Final project report. ERP-02D-P57. Nov. 2006.

6. FISH, WILDLIFE AND PLANT SPECIES

6.6 Other Species Addressed

The ERP funded additional studies of additional species in MSCS designations other than "Recovery." These species include:

- Western pond turtle (MSCS designation: Maintain)
- Foothill yellow-legged frog (MSCS designation: Maintain)
- California tiger salamander (MSCS designation: Maintain)
- Western spadefoot toad (MSCS designation: Maintain)
- California Yellow Warbler (MSCS designation: Contribute to Recovery)
- Saltmarsh Common Yellowthroat (MSCS designation: Contribute to Recovery)
- Black-headed Grosbeak (No MSCS designation)
- Tricolored Blackbird (MSCS evaluated species, no designation)
- Riparian Brush Rabbit (MSCS designation: Contribute to Recovery)
- San Joaquin Riparian Woodrat (MSCS designation: Contribute to Recovery)
- Crampton's tuctoria (MSCS designation: Contribute to Recovery)
- Colusa Grass (MSCS designation: Maintain)
- Alkali Milk Vetch (MSCS designation: Contribute to Recovery)

ERP funded a study, *Genetic Identification of Management Units for Watershed-Dependent Species of Special Concern* (**ERP-01-N43**), which characterized the population genetic structure of several species of Central Valley amphibians, reptiles, and songbirds, in order to provide resource managers with recommendations on whether each of these species should be managed as a single unit, or whether there is enough genetic differentiation within these species' populations to recommend that distinct populations be managed separately. Some of the findings follow:

The **western pond turtle** (*Clemmys marmorata*) is composed of at least four distinct lineages: 1) a Northern lineage with populations from Washington south to San Luis Obispo County; 2) a Southern lineage with populations south of the Tehachapi Mountains, west of the Transverse Range, and south to Baja, California, Mexico; 3) a Santa Barbara lineage from a limited region in Santa Barbara and Ventura Counties; and 4) a San Joaquin Valley lineage from the southern portion of the Central Valley. The recommendation to resource managers is that the Northern, Southern, and Santa Barbara linkages be managed as distinct entities, and that the San Joaquin Valley lineage be managed as two entities: a San Joaquin River Basin lineage (populations from the mid-Central Valley south to the Kings River) and a Tulare Basin lineage (populations south of the Kings River to the southern end of the San Joaquin Valley).

The **foothill yellow-legged frog** (*Rana boylii*) includes at least five management units including: 1) a Northern Oregon unit composed of the South Santium River population; 2) a Central-Northern Sierra Nevada unit composed of populations from Jose Creek and the American, Bear, Calaveras, Feather, and Yuba Rivers; 3) a Central Coast unit including the Arroya Leona, San Benito, and Los Burros drainages; 4) a Tulare Basin unit which includes the Kern River population; and 5) a Monterey Coast Unit which includes Dutra Creek populations. A boundary for each of these units is not yet known, and requires further study.

Findings for the **California tiger salamander** (*Ambystoma californiense*) demonstrate that: 1) populations from northern Santa Barbara County are distinct for both pure and hybridized populations; 2) populations from the southern San Joaquin Valley (Fresno, southern Madera, and northwest Tulare Counties), south of the Fresno River, form a distinct group requiring separate management; 3) populations from the eastern and western sides of the Central Valley are genetically distinct; 4) populations from Sonoma County are genetically distinct; and 5) populations from the Bay Area (Diablo range), Central Valley (Yolo County south to northern Madera County), and Central Coast range (Monterey, San Benito, and surrounding counties) are all distinct genetic units, and should be managed separately. Hybridization between the California tiger salamander and non-native barred tiger salamanders is extensive throughout the Salinas River drainage, and all populations from this drainage should be viewed as genetically invaded, non-natives.

Findings for the **western spadefoot frog** indicate hybridization among three species of spadefoot frogs (*Spea bombifrons, Spea hammondii, and Spea intermontana*). However, *Spea hammondii* populations north of the Transverse Range most likely have not hybridized with other *Spea* species, and should be managed as three distinct units, including: 1) a Santa Barbara unit composed of populations from a geographically restricted area north of the Santa Ynez mountains; 2) a San Joaquin Valley unit composed of populations from the Mokelumne River, south to the southern end of the San Joaquin Valley; and 3) a Sacramento Valley unit composed of populations from the Mokelumne River, north to the northern extent of the species' range.

With respect to birds, this study found very little evidence of fine-scale population structuring in any of the four bird species studied (**yellow warbler** (*Dendroicha petechia*), **common yellowthroat** (*Geothlypis trichis*), **black-headed grosbeak** (*Pheucticus melanocephalus*), and **tricolored blackbird** (*Agelaius tricolor*), suggesting considerable movement between sites and few, if any, isolated populations. Therefore, at least in the Central Valley, each species should be managed as a single unit, rather than managing each fragmented population of each species separately.

However, researchers note observations that strongly suggest two distinct populations of **tricolored blackbirds** – one spanning north of the Tehachapi Pass up through the Central Valley, and the other restricted to southwestern California counties – which do not move between sites and might actually be separate subspecies (Smith et al. 2006).

Several projects (**ERP-02D-C11**, **ERP-01-N11**, **ERP-01-N08**, **ERP-97-B04**) acquired fee title or conservation easements on acreage along the Stanislaus and San Joaquin rivers, including near Caswell State Park, to provide secure sites for release of captive-bred **riparian brush rabbit** (*Sylvilagus bachmani riparius*), and to restore riparian and floodplain habitat to benefit brush rabbits as well as **riparian woodrat** (*Neotoma fuscipes riparia*)**.**

The At-Risk Plant Species, Habitat Restoration and Recovery, and Non-Native Invasive Species Management Project (**ERP-02-P46**) provided funding for the Yolo County Planning and Public Works Department to gain ownership and management responsibilities for a 320 acre site in Yolo County at the McClellan Air Force Base's Davis Communication Site near Davis. This site supports approximately 17 acres of alkali vernal pools and several rare plants and animals. The site also contains the largest known extant population of **Crampton's tuctoria** (*Tuctoria mucronata*) (ranging from 10,000 to over 150,000 plants). It also benefits **Colusa grass** (*Neostapfia colusana*) and **alkali milk-vetch** (*Astragalus tener*). The site also includes other endangered vernal pool endemic species including vernal pool tadpole shrimp and vernal pool fairy shrimp. The grass dominated uplands provide foraging habitat for Swainson's hawk (*Buteo swainsonii*) and western burrowing owl (*Athene cunicularia*). The site is adjacent to the Grasslands Regional Park, another 320 acre parcel also owned by Yolo County.

Project Summary Table

Table 1. Other Species Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-02-P46	**At-Risk Plant Species, Habitat Restoration and Recovery, and Non-Native Invasive Species Management.** This project worked to protect, manage and restore habitat quality of vernal pool wetlands, particularly for Crampton's tuctoria and alkali milk vetch, through eradication of non-native invasive species on 320 acres in Yolo County.	6/30/2006	$400,000	Complete.
ERP-02D-C11	**Recovery Implementation for Riparian Brush Rabbit and Riparian Woodrat on the Lower Stanislaus River** This project restored riparian habitats along the lower Stanislaus and San Joaquin Rivers.	11/30/2008	$5,465,944	Project ongoing; status listed as 18% complete as of September 2007.

Table 1. Other Species Project Summary

ERP Project Number	Project Name and Description	End Date	Total Funding	Project Status
ERP-01-N43	**Genetic Identification of Management Unit for Watershed-Dependent Species of Special Concern** This study tested competing hypotheses about the relative importance of geographic distance versus geographic barriers in producing population genetic structure. The project characterized spatial population structure in Central Valley amphibians, reptiles, and songbirds by using two complementary molecular markers to elucidate the genetic structure of Central Valley populations in three species of amphibians, one species of reptile, and four passerine songbird populations. The resulting genetic information can be used to provide resource managers with information, linking population structure with demographic processes.	12/30/2005	$832,000	Complete.
ERP-01-N11	**Habitat Acquisition for Riparian Brush Rabbit and Riparian Woodrat** This project acquired fee title or conservation easements on 400 acres of riparian habitat to provide secure sites for release of captive-bred riparian brush rabbits.	12/31/2006	$2,720,085	Complete.
ERP-01-N08	**San Joaquin River NWR Riparian Habitat Protection & Floodplain Restoration Project – Phase 2** This project funded the easement acquisition of approximately 400 acres of habitat adjacent to the San Joaquin River NWR; restored 1,142 acres of riparian and wetlands habitat on refuge lands; and included a pilot re-introduction of riparian brush rabbits onto refuge lands and biological monitoring and evaluation.	12/31/2006	$7,646,233	Complete. Several properties acquired and restored; riparian brush rabbit use monitored.
ERP-97-B04	**San Joaquin River National Wildlife Refuge Riparian Habitat Protection and Floodplain Restoration Project – Phase 1** This project acquired and planned restoration of additional floodplain lands along the San Joaquin River for USFWS San Joaquin National Wildlife Refuge.	3/31/2002	$10,647,000	Complete. Some properties acquired and restored.

References

Smith, T. et al. 2006. Genetic Identification of Management Units for Watershed-Dependent Species of Special Concern. Final project report. ERP-01-N43. May 2006.