Agenda Item 2
Attachment 9

Flex your POWER

State of California
Department of Fish and Game

Memorandum

Date: August 19, 2008

To: John Kirlin, Executive Director
Delta Vision Task Force
1416 Ninth Street, Suite 1311
Sacramento, CA 95814

From: Carl Wilcox, Branch Chief
RMPD/Water Branch
Department of Fish and Game
830 S Street
Sacramento, CA 95811

Subject: The Purpose of this memorandum is to transmit to you the most current staff draft Ecosystem Restoration Program Conservation Strategy for Stage 2 Implementation, for the Sacramento-San Joaquin Delta and Suisun Marsh and Bay Planning area, (ERP Conservation Strategy).

The ERP Conservation Strategy is the product of work conducted over the last several years by the Department of Fish and Game (DFG) in collaboration with the National Marine Fisheries Service (NMFS) and US Fish and Wildlife Service (USFWS), which together comprise the three implementing agencies for the program. It provides the foundation for regional implementation of the ERP guided by a science based adaptive management approach designed to improve aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of fish and wildlife species. It represents a "single blueprint" for conservation and recovery of species and will integrate the NMFS recovery plan for Central Valley salmonids and the USFWS Delta Native Fishes Recovery Plan, once these plans are completed. While the ERP Conservation Strategy currently focuses on the Delta and Suisun Marsh it will be expanded to include the tributaries to the Delta.

The ERP Conservation Strategy has been developed to guide future ERP implementation based on evaluation of Stage 1 implementation, the first seven years of CALFED, and new information. It is a blueprint under which more detailed planning efforts such as the Bay Delta Conservation Plan (BDCP) can be accommodated. The BDCP is currently evaluating specific detailed actions which would implement at least in part those described more generally in the Conservation Strategy. In particular BDCP will be addressing the issues of conveyance and flows as a component of ecosystem restoration. The ERP Conservation Strategy represents the perspectives of the three fish agencies on what is needed at a programmatic level to achieve biological conservation and management goals in the Delta.

The draft staff ERP Conservation Strategy has recently undergone significant revision by the Department and is undergoing review by the three implementing agencies for adoption in September. We are providing this draft of the ERP Conservation Strategy to the Delta Vision Blue Ribbon Task Force for parallel review and for your consideration as the Ecosystem element of the broader California Delta Ecosystem and Water Plan currently envisaged in the Draft Strategic Plan.

The Department is available to discuss this conservation strategy and its use in more detail. If you have any questions, please do not hesitate to call me at 916-445-1231.

Attachment

DFG ADMINISTRATIVE DRAFT

NOT FOR CITATION OR ATTRIBUTION

Ecosystem Restoration Program (ERP)

Conservation Strategy for Stage 2 Implementation

Sacramento-San Joaquin Delta
and
Suisun Marsh and Bay
Planning Area

Version 2.2

Prepared by

California Department of Fish and Game

August 18, 2008

FOREWORD

This conservation strategy is being developed in concert with numerous other planning efforts for the Sacramento-San Joaquin Delta portion of the San Francisco Bay-Delta estuary. As these planning processes are still ongoing, this conservation strategy will be revised and updated periodically over the course of Stage 2 implementation as new information becomes available, and as scientific evaluation tools (e.g. conceptual models) are revised to reflect the most current scientific understanding of ecosystem processes, habitats, stressors, and species interactions. At this time, however, the document provides a general overview of how the Ecosystem Restoration Program (ERP) proposes to address the critical environmental conditions in the Delta and Suisun Marsh/Bay during the first phase (Phase 1) of Stage 2 implementation (2009-2020).

There are several key variables that are expected to change over the course of Phase 1, which will provide justification for specific restoration actions to be undertaken in the near- and longer-term implementation of the ERP through 2030. Specifically:

Relationship to other geographic areas. The spatial extent of the ERP includes the Sacramento and San Joaquin Valleys in addition to the Bay-Delta estuary, and the ERP implementing entities recognize how conditions in the estuary are directly influenced by the manner in which water and species are managed upstream. Conservation strategies for these upstream areas will be forthcoming as part of ongoing ERP implementation.

Conveyance assumptions. This conservation strategy is based on the assumption that the most promising approach for achieving both ecosystem and water supply goals for the Delta involves a conveyance system with new points of diversion, dependent upon design, operational, and institutional considerations currently under development. This includes construction and operation of a new point (or points) of diversion in the north Delta, on the Sacramento River, and an isolated conveyance facility around the Delta. In addition, modifications to existing export facilities in the south Delta would be pursued to reduce entrainment and otherwise improve the State Water Project's (SWP) and Central Valley Project's (CVP) ability to convey water through the Delta. This assumption dictates that in the short-term, continued conveyance of water through the Delta will accommodate habitat restoration actions mainly in the north Delta (i.e. the North Delta Ecological Management Unit [EMU]) and Suisun which are further removed from the influence of the south Delta export facilities. Over the longer-term, if an isolated conveyance system becomes operational, restoration of habitat in the South, Central/West, and East Delta EMUs would be more widely pursued.

Development of short- and longer-term restoration actions. There are a number of conceptual models that in development, which are being used to analyze potential ecosystem restoration actions. Over the next few months, these models will be used to analyze actions under discussion in parallel planning processes (i.e. the Delta Vision Ecosystem Work Group and the Bay-Delta Conservation Plan), as well as to develop and refine restoration actions in a broader ecosystem context than that addressed by these other efforts. While the initial focus of restoration actions in the Delta and Suisun Marsh/Bay will be on improving aquatic conditions, restoration of terrestrial habitats will be considered on a case-by-case basis in terms of their potential to improve aquatic conditions, build land elevations on subsided Delta islands, and/or accommodate "shifts" in habitat areas due to future sea level rise.

Development of performance measures. The conceptual models will be used to develop and implement performance measures by which ERP implementation will be evaluated over time. Staff resources are in the Governor's 08-09 budget to develop specific ecological performance measures in the future.

Species information. Much has been learned about key Delta resident and migratory species in the last ten years, and this information is being compiled into "species-stressors" tables that identify the importance, level of understanding, and certainty/predictability of those species' interactions with environmental conditions. As this information is developed for both aquatic and terrestrial species over time, it will be used to inform and prioritize management decisions relating to ecosystem restoration actions in the Delta and Suisun Marsh/Bay.

Governance. It is expected that ERP will continue to be implemented by the three State and federal fisheries agencies responsible for species protection and recovery: California Department of Fish and Game (DFG), National Marine Fisheries Service (NMFS), and U.S. Fish and Wildlife Service (USFWS). It is envisioned that this ERP Conservation Strategy focused on the Delta and Suisun Marsh/Bay could serve as the "ecosystem" component of a comprehensive program of governance toward a sustainable Delta (i.e. e.g. the California Delta Ecosystem and Water Plan envisioned by the Delta Vision process); the other "co-equal" goal to be pursued as part of this future program is water supply reliability.

It is important to note that the Delta Vision process, in developing its comprehensive program for a sustainable Delta, has adopted a longer-term perspective (50 to 100 years) than that originally adopted by the ERP when it was certified as part of the CALFED Record of Decision in 2000 (30 years). However, in crafting the conservation strategy for implementing the ERP over the remaining 20+ years of the program, the ERP implementing agencies have adopted the longer-term perspective as well. This will be evident in the discussions within this document relating to sea level rise and climate change, and how ecosystem restoration activities will proceed in anticipation of these changes over the next 50-100 years. The adaptive management framework laid out in this document will include "phased" implementation of ERP as the initial "ecosystem enhancement" element that could be a more comprehensive program, allowing for additional ecosystem enhancement components to be developed in the future if it is discovered that ongoing ERP implementation is not achieving desired Delta ecosystem objectives. This is discussed in further detail in the "Adaptive Management" section of this document.

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Introduction

This document describes the Conservation Strategy for Stage 2 specifically for the Sacramento-San Joaquin Delta and Suisun Marsh and Bay (hereafter "Delta and Suisun Planning Area" or "planning area"). It was developed by the California Department of Fish and Game (DFG), U.S. Fish and Wildlife Service (USFWS), and National Marine Fisheries Service (NMFS), collectively referred to as the ERP Implementing Agencies. Chapters that focus on the remaining regions in the ERP Focus Area will be addressed in forthcoming documents and will be specific to each of the other ERP regions: Sacramento Valley, San Joaquin Valley, East Side Tributaries, and North San Francisco Bay (Figure 1). Together these documents will provide a comprehensive ecosystem conservation strategy for the Central Valley and North San Francisco Bay.

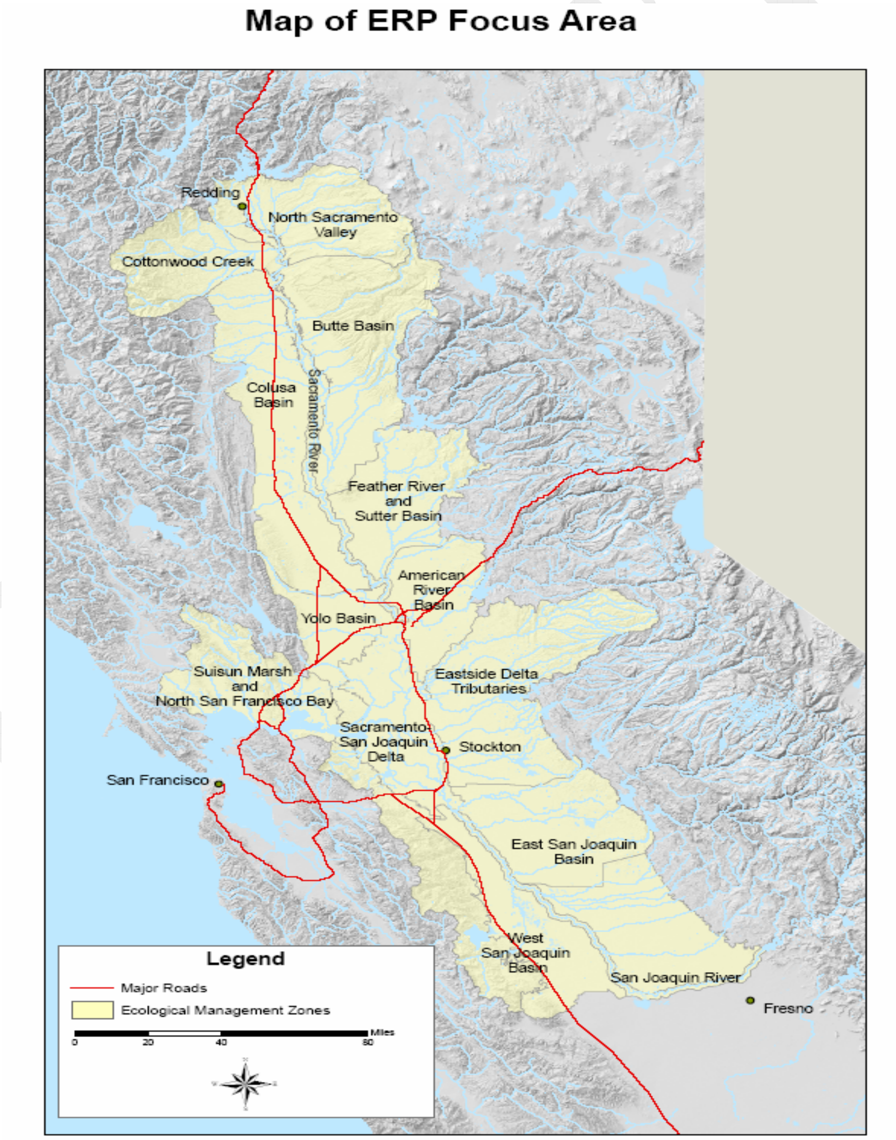


Figure 1. Map of CALFED ERP Focus Area

The purpose of this document is to describe the ERP Implementing Agencies' ecosystem restoration goals, objectives, and priorities for the Delta and Suisun Planning Area moving into Stage 2 of CALFED. It is intended for use by all parties interested in resource conservation and management within the planning area, including federal, State and local agencies, nongovernmental organizations, stakeholders, and the general public. The conservation strategy should be used as a common vision to facilitate coordination and integration of actions, not only within CALFED, but among all resource planning, conservation, and management decisions affecting the Delta and Suisun Planning Area. The conservation strategy is built upon information from CALFED Stage 1 evaluations, review of current ecological conditions, coordination with related programs and planning efforts, assessment of potential future actions, and input from stakeholders and the public.

Background

CALFED is a 30-year regulatory federal and State program with objectives to:

- Provide good water quality for all beneficial uses.
- Improve and increase aquatic and terrestrial habitats and improve ecological functions in the Bay-Delta to support sustainable populations of diverse and valuable plant and animal species.
- Reduce the mismatch between Bay-Delta water supplies and current and projected beneficial uses dependent on the Bay-Delta system.
- Reduce the risk to land use and associated economic activities, water supply, infrastructure and the ecosystem from catastrophic breaching of Delta levees.

The program objectives (Appendix A) have been implemented among numerous CALFED Program elements since the CALFED Program's Record of Decision (ROD) was certified in 2000 (CALFED 2000e). The Ecosystem Restoration Program (ERP) is the principal CALFED Program component designed to restore the ecological health of the Bay-Delta ecosystem. The approach of the ERP is to restore or mimic ecological processes and to increase and improve aquatic and terrestrial habitats to support stable, self-sustaining populations of diverse and valuable species. The ERP also is intended to help fulfill the mission of improving water management for beneficial uses of the Bay-Delta system. .

Consistent with direction in the CALFED programmatic biological opinions (BOs) (CALFED 2000f, g) and Natural Community Conservation Plan Determination (DFG 2000), Programmatic Environmental Impact Statement/Environmental Impact Report (PEIS/EIR) (CALFED 2000i), and ROD, the CALFED Stage 1 evaluation was set for seven years. The subsequent Stage 2 Conservation Strategy will be collaboratively developed by the CALFED Implementing Agencies (CALFED 2000a-g, i). To this end, the ERP is conducting a set of evaluations to ascertain progress on restoration and regulatory compliance during Stage 1 to inform conservation planning for transitioning into Stage 2. The evaluations also will identify other related programs and planning efforts that need to be coordinated with ERP planning, and encourage involvement of the other programs, stakeholders, and public. The ERP Stage 1 assessment will evaluate:

- Progress towards achieving Multi-Species Conservation Strategy (MSCS) CALFED 2000d) Milestones
- Efficacy of the Environmental Water Account (EWA)
- Progress of overall ERP implementation
- Progress towards achieving Key Planned Actions provided for in the BOs

The ERP Conservation Strategy is built upon a foundation of key CALFED Program documents including the ERPP, Volumes 1 and 2 CALFED 2000a, b); MSCS; and Strategic Plan for the ERP (Strategic Plan) (CALFED 2000c), but will be developed adaptively in response to information gathered from research and other activities which occurred during Stage 1.

Ecosystem Restoration Program Plan

Volume 1 of the Ecosystem Restoration Program Plan (ERPP) describes the organization of the program, visions for ecological processes and functions, fish and wildlife habitats and species, and stressors that impair the health of the processes, habitats, and species. The visions presented in ERPP Volume 1 are the foundation of the ERP and display the relationships between the many ecosystem elements. Volume 2 of the ERPP presents visions for the 14 ecological management zones (Figure 1) and their respective ecological management units. Each ecological management zone vision contains a brief description of the management zone and units, important ecological functions associated with the zone, significant habitats, species that use the habitats, and stressors that impair the functioning or utilization of the processes and habitats. ERPP Volume 2 presents restoration targets, programmatic actions, and conservation measures that describe the ERP approach and balance and integrate needs of the MSCS. Rationale also is contained in Volume 2 that clarifies, justifies, and supports targets and actions.

Multi-Species Conservation Strategy

To meet the requirements of the federal Endangered Species Act (ESA), California Endangered Species Act (CESA), and the Natural Community Conservation Planning Act (NCCPA), the MSCS provides a two-tiered approach for evaluating potential impacts to specified biological resources from implementing CALFED projects. The first tier is a program-level evaluation of CALFED similar to programmatic environmental impact documents under NEPA and CEQA. The second tier is the project-level evaluation in a process in which an Action Specific Implementation Plan (ASIP) is prepared for each CALFED action or group of related actions proposed for implementation.

The MSCS identified and evaluated 244 special status species and 20 NCCP communities that could be affected by CALFED program implementation. Conservation goals for each species and community were identified as well. Species goals are: 1) recovery of 19 evaluated species ("R species"), 2) contribute to recovery of populations for 25 evaluated species ("r species"), and 3) maintain existing levels of populations and habitats for 155 evaluated species ("m species"). Goals for Natural Community Conservation Plan (NCCP) communities fall into four categories: 1) substantially increase extent and quality of habitat; 2) protect, enhance, and restore habitat; 3) avoid, minimize, and compensate for loss of habitat; and 4) avoid, minimize, and compensate for loss of individuals where evaluated species are affected.

The MSCS (Table 3-1) lists prescriptions for achieving species goals, which are subject to modification through adaptive management. Recovery criteria may be revised as a result of additional research, monitoring, and data interpretation. For example, recovery plans currently being developed for many tidal marsh species may lead to new recovery criteria. Current prescriptions for NCCP goals are enumerated in Table 3-2 of the MSCS. The MSCS also identified two types of conservation measures contributing toward achieving species and community goals. These included measures to avoid, minimize, and compensate for adverse effects on NCCP communities and evaluated species, and measures to enhance NCCP communities and evaluated species.

Strategic Plan

The ERPP Strategic Plan (Strategic Plan) provides ERP goals and objectives and the scientific and practical framework for implementing the restoration of the Bay-Delta watershed. The six strategic goals that define the scope of the program are further divided into more specific strategic objectives, each of which are intended to help determine whether or not progress is being made toward achieving the respective goal. Specific actions based on the ERPP Volumes 1 and 2 also are identified in the Strategic Plan. The six ERP program goal statements enumerated in the Strategic Plan are to:

- Achieve recovery of at-risk native species dependent on the Delta and Suisun Bay as the first step toward establishing large, self-sustaining populations of these species; support similar recovery of at-risk native species in San Francisco Bay and the watershed above the estuary; and minimize the need for future endangered species listings by reversing downward population trends of native species that are not listed.

- Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

- Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

- Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

- Prevent the establishment of additional nonnative invasive species and reduce the negative ecological and economic impacts of established nonnative species in the Bay-Delta estuary and its watershed.

- Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

Since completion of the Strategic Plan, implementation of restoration activities has progressed, but some objectives, particularly of protecting and recovering at-risk Delta aquatic species, have not been achieved. Some of these species have further declined, such as species of the Pelagic Organism Decline (POD) in the Delta (e.g. delta smelt, longfin smelt, threadfin shad, and striped bass; neither threadfin shad nor striped bass were slated for protection or recovery under the MSCS) (IEP 2007). Although it would be premature to evaluate ERP actions in terms of recovery, pelagic organism and salmonid population declines pose the need for serious consideration of the effectiveness in reaching program goals through Stage 1. This kind of evaluation has come out of the End of Stage 1 Assessment reports (DFG 2008b). Planning efforts, restoration activities, and scientific research conducted in Stage 1 have benefited at-risk species, and include:

- Enabling a better understanding of important processes such as hydrodynamics, temperature regimes, and instream flow.
- Assessment of hatchery impacts on natural Chinook salmon and steelhead populations.
- Development of methodology to culture all life stages of delta smelt.
- Assessment of various contaminant effects on aquatic species.
- Planning and on-ground restoration of aquatic and terrestrial habitat.
- Increasing understanding of salmonid populations through monitoring and genetic studies.
- Increased understanding of the value of floodplains to native fish species

Relationship of ERP Conservation Strategy for the Delta and Suisun Planning Area to Other Planning Efforts

The initial CALFED planning documents, including the ERPP, were completed in 2000. Since 2000, Program Plans were prepared which reviewed program progress annually. Work plans were then prepared each year in response to the previous year results, recommendations, and budget constraints. In keeping with the dynamic nature of the program, and mandates to manage the ERP adaptively, information will be continually incorporated ERP planning for the Stage 2. This conservation strategy is a biological view of the most promising ecosystem restoration opportunities in the Delta and Suisun Marsh, and provides the rationale for Delta-specific restoration actions. However, the Delta is a complex system that is influenced by land and water use and socio-economic factors. The conservation strategy is being developed with recognition of these factors and will be updated periodically to accommodate future changes using standard adaptive management techniques which incorporate scientific and stakeholder input.

Several concurrent planning efforts, such as the forthcoming NMFS and USFWS recovery plans for federally listed Delta salmonid and other native fishes, Delta Risk Management Strategy (DRMS), Delta Vision, and Bay-Delta Conservation Plan (BDCP) are evaluating the status of resources in the Delta, future use of these resources, and risk to the Delta as a result of controllable and uncontrollable drivers of change. Information should flow both ways between these efforts and the ERP Conservation Strategy (Figure 2). Because the ERP Conservation Strategy represents the position of the ERP Implementing Agencies in planning for ecosystem restoration and land and water development in the planning area, it is the intent of the ERP

Implementing Agencies that the Conservation Strategy will provide a biological foundation for these other planning efforts.

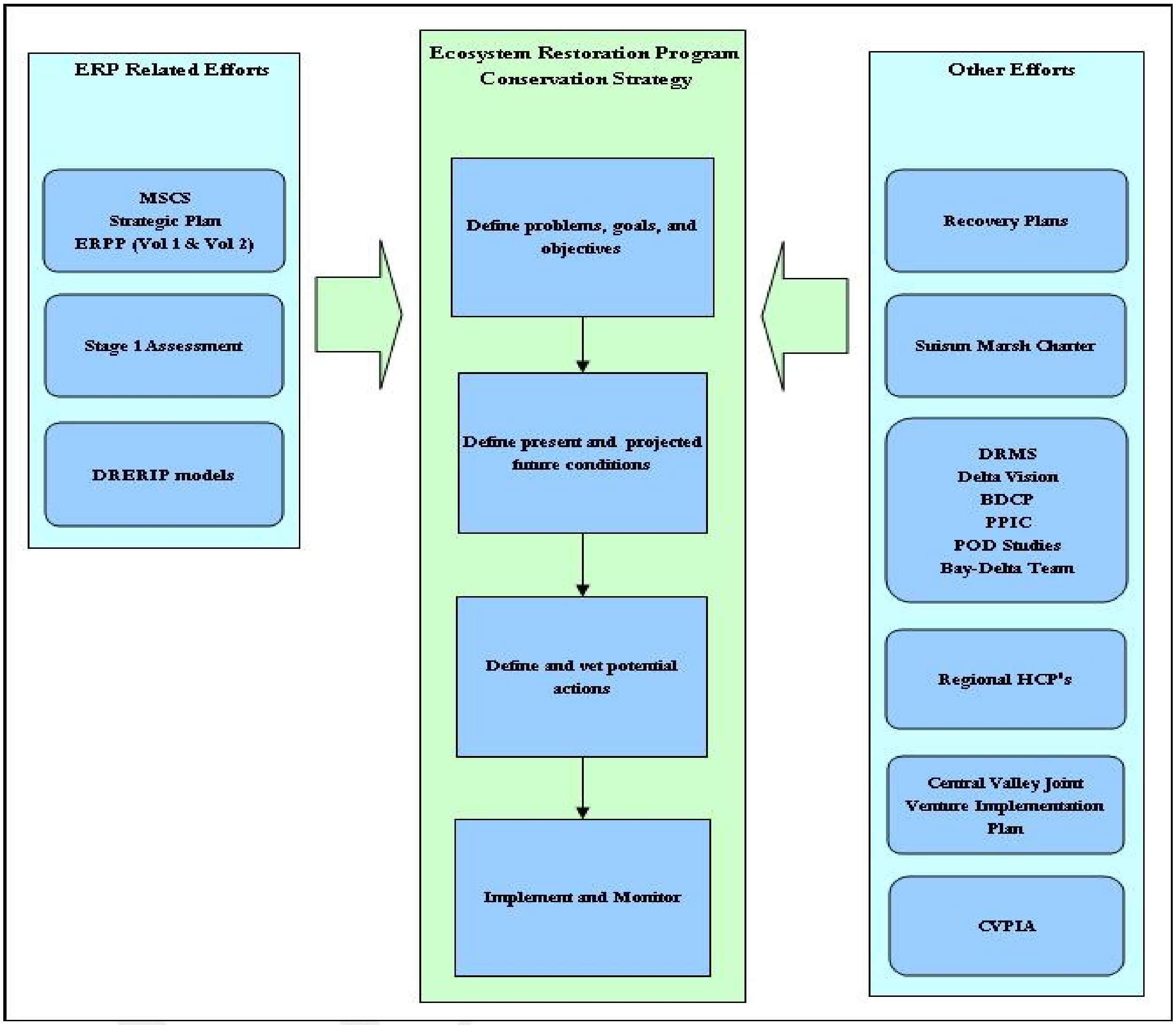


Figure 2. Relationship of ERP Conservation Strategy to other planning efforts

Delta Vision

The intent of the Delta Vision process is to identify a strategy for managing the Sacramento-San Joaquin Delta as a sustainable ecosystem that will continue to support environmental and economic functions critical to the people of California. The Delta Vision Blue Ribbon Task Force (Task Force), a Governor-appointed panel, is charged with developing recommendations on priority actions that should be taken to achieve a sustainable Delta in the long-term. The Delta Vision has a broader focus than the ERP, and the Task Force will issue recommendations that address the full array of natural resources, infrastructure, land use, and governance issues necessary to achieve a sustainable Delta. Delta Vision is based on a growing consensus that: environmental conditions and the current water conveyance configuration of the Delta are not sustainable for environmental and economic purposes; current land and water uses and related services dependent on the Delta are not sustainable based on current management practices and regulatory requirements; major “drivers of change” (e.g. seismic events, land subsidence, sea level rise, regional climate change, and urbanization) will impact the Delta in the future; the current fragmented and complex governance systems within the Delta are not conducive to effective management of the Delta in light of these threats; and failure to address these challenges and threats could result in significant environmental and economic consequences.

The Task Force’s Delta Vison which included recommendations for natural resource values and functions, services, and management practices that should be prioritized for future management toward a sustainable Delta were submitted to the Delta Vision Committee and Governor in late 2007; the key recommendation is that “the Delta ecosystem and a reliable water supply for California are the primary, co-equal goals for sustainable management of the Delta” (Delta Vision Blue Ribbon Task Force 2007). A Strategic Plan for a Sustainable Delta which will provide implementing actions in accordance with those recommendations is due to the Governor by December 31, 2008. For more information, go to www.deltavision.ca.gov.

The Delta Vision Committee, whose participants include the Secretaries for Resources, Business Transportation and Housing, Food and Agriculture, California Environmental Protection Agency, and Public Utilities Commission will use the recommendations of the Task Force in making recommendations to the Governor on actions to be taken to ensure a sustainable Delta.

Delta Risk Management Strategy (DRMS)

As mentioned above, there is great interest in developing a Delta Vision that addresses long-term sustainability of the Delta in the future for environmental and economic purposes. The CALFED ROD required the completion of a risk assessment that would evaluate sustainability of the Delta, as well as assess major risks to Delta resources and infrastructure from flooding, seepage, subsidence, and earthquakes.

Assembly Bill 1200, chaptered in October 2005, requires that DWR evaluate the potential impacts on Delta resources and infrastructure, based on 50-, 100-, and 200-year projections, from subsidence, earthquakes, floods, climate change and sea level rise, or a combination of these factors. DWR and DFG would then develop principal options for the Delta and evaluate and comparatively rate the options with regard to these variables. The geographic area included within this evaluation is the Suisun Marsh east of the Benicia-Martinez Bridge on Interstate 680, and the Sacramento-San Joaquin Delta as legally defined in Water Code section 12220 et seq. DFG’s and DWR’s report was submitted to the Legislature in early 2008 and has been provided to the Task Force for consideration in the Delta Vision. For more information, go to www.drms.water.ca.gov.

Bay-Delta Conservation Plan (BDCP)

The BDCP is an applicant-driven process through which certain activities (e.g., water export operations of the State Water Project and Central Valley Project and power plant operations of Mirant Energy in the Pittsburg/Antioch area) would authorized under FESA,CESA, and the Natural Community Conservation Plan Act (NCCPA) in the context of an overall conservation strategy for the covered listed species. Development of the BDCP is guided by a Steering Committee which consists of numerous applicants seeking incidental take coverage, as well as

State and federal fisheries agencies and nonprofit groups and other interested stakeholders. The intent is to develop a joint Natural Community Conservation Plan (NCCP) and Habitat Conservation Plan (HCP).

In accordance with the NCCPA, the BDCP Steering Committee members signed a Planning Agreement in 2006, which included preliminary identification of the planning area, covered activities, covered species, and natural communities that would be included in the conservation plan.

In the first half of 2007, the Steering Committee identified a number of stressors affecting the list of aquatic species preliminarily identified in the Planning Agreement, and came up with four conceptual options for water conveyance through or around the Delta to address those stressors. In the latter part of 2007, a coarse scale evaluation of the four conveyance options was completed. Based on that evaluation the Steering Committee agreed that the Dual Conveyance Option provided the best opportunity to meet the objectives of the Planning Agreement. During 2008, operational modeling will be conducted to evaluate conveyance options and a detailed conservation strategy will be developed. By early 2009, the NEPA/CEQA environmental documentation will begin, with the expectation of having the final document certified and all necessary permits in hand by the end of 2010. For more information, go to www.resources.ca.gov/bdcp/.

Central Valley Project Improvement Act (CVPIA) Programs

The Central Valley Project Improvement Act (CVPIA), passed in 1992, mandates changes in management of the Central Valley Project, particularly for the protection, restoration, and enhancement of fish and wildlife. Among other provisions relating to water transfers and contracts, CVPIA calls for: 800,000 acre-feet of water dedicated to fish and wildlife annually; special efforts to restore anadromous fish population by 2002; a restoration fund financed by water and power users for habitat restoration and enhancement and water and land acquisitions; and firm water supplies for Central Valley wildlife refuges (USBR 2008).

There are a number of CVPIA programs which have been integrated with ERP implementation during Stage 1, including (but not limited to) the Anadromous Fish Restoration Program (AFRP) which addresses environmental limiting factors for anadromous fish; Dedicated Project Yield which augments flows on CVP-controlled streams and moderates CVP pumping from the Delta; and the Anadromous Fish Screen Program (AFSP) which assists in the screening of water diversions to protect fish (DFG 2008b).

Public Policy Institute of California (PPIC) Reports

Public Policy Institute of California and a team of experts from the University of California, Davis, evaluated the vulnerability of the Sacramento–San Joaquin Delta to a variety of risk factors and described a series of options for addressing current and likely future problems. This report, *Envisioning Futures for the Sacramento–San Joaquin Delta* (Lund et al. 2007), describes why the Delta matters to Californians and why the region is currently in a state of crisis, from threatened freshwater supplies for the whole State, to potential extinction of numerous fish species. The report concludes with recommendations for several actions, some related to the use of technical and scientific knowledge, and others to design of governance and finance policies.

The PPIC and UC Davis Team continued their analysis of future changes to the Delta, and response to those changes, in another report, *Comparing Futures for the Sacramento-San Joaquin Delta* (Lund et al. 2008). In that report, they focused on the question of which water management strategies would best met the co-equal goals of environmental sustainability and water supply reliability. In comparing different water management alternatives, the team concludes that a peripheral canal is the best option of all the export alternatives for achieving the State's economic and environmental objectives.

Pelagic Organism Decline (POD)

Abundance indices calculated by the Interagency Ecological Program (IEP) through 2005 suggest recent marked declines in numerous pelagic fishes in the Delta and Suisun Bay (IEP 2007a). Although several species show evidence of long-term declines, recent low levels were unexpected given the relatively moderate winter-spring flows of the past several years.

In response to these changes, the IEP formed a Pelagic Organism Decline (POD) work team to evaluate the potential causes of the decline. Issues emerging from POD studies, most already included in ERP documents, emphasize a subset of stressors, namely ecological foodweb declines and invasive species, toxic pollution, and water operations (IEP 2007b). The POD work team is conducting investigations along multiple lines of inquiry, including the effects of exotic species on food web dynamics, contaminants, water project operations, and stock recruitment.

State and Regional Water Quality Control Boards' Bay-Delta Team

In response to concerns over whether beneficial uses of the Sacramento-San Joaquin Delta are being protected, staff from the State Water Resources Control Board and the Central Valley and San Francisco Regional Water Quality Control Boards (Water Boards) formed a Bay-Delta Team to improve coordination of their activities in the estuary. In 2007, the Bay-Delta Team began developing a long-term program for addressing impacts to beneficial uses of Delta water, and circulated a "Delta Actions Resolution" (Resolution no. R5-2007-0161). This resolution was adopted by all three Water Boards by January 2008, and in adopting this resolution, the Bay-Delta Team was tasked with developing a strategic workplan that prioritizes actions, lays out implementation schedules, and identifies existing and needed resources.

Initial high-priority actions include (but are not limited to):

- Development of a comprehensive long-term regional monitoring program for the Delta, to compile data on contaminants in sediments, water, and aquatic organisms and assess that data on a regular basis.
- Monitoring to characterize discharges from Delta islands, and working with the Department of Pesticide Regulation and Delta County Agricultural Commissioners to determine whether additional enforcement or restrictions on in-Delta pesticide use is warranted.
- Assessment of the potential impact of ammonia on Delta species and food web organisms.
- Evaluation of Contra Costa Power Plant's potential impacts on species, with the objective of obtaining an updated incidental take permit.
- Continued implementation of numerous Total Maximum Daily Load (TMDL) programs for constituents that impair aquatic life beneficial uses in the Delta (including OP pesticides, mercury/methylmercury, low dissolved oxygen, salt and boron, selenium, and bacteria).

- Development of a Central Valley Salinity Management Plan and a Central Valley Drinking Water Policy [Larsen 2008].

Suisun Marsh Implementation Charter

- The Habitat Management, Preservation, and Restoration Plan for Suisun Marsh (Suisun Marsh Plan) is being developed by The Suisun Marsh Charter Group Principal Agencies, a team of local, State, and federal agencies focused on improving the health of Suisun Marsh. The Suisun Marsh Plan is intended to provide a framework for ongoing management of Suisun Marshas habitat for waterfowl, plus existing wildlife and endangered species habitats, maintain and improve strategic exterior levees to protect water quality, restore tidal marsh and other ecosystems, and improve water quality. The planning process will result in a draft programmatic EIS/EIR (PEIS/EIR), with action-specific elements in late 2008 or early 2009 (Suisun Marsh Charter Principal Agencies 2007). Figure 2 includes a diagram of the relationship of the ERP Conservation Strategy for the Delta and Suisun Planning Area with related planning efforts.

Federal Recovery Plans

- ***US Fish and Wildlife Service (FWS) Delta Native Fishes Recovery Plan.*** Since the original recovery plan was released in 1996 (USFWS 1996), significant new information regarding the status, biology, and threats to Delta native species has emerged. Ongoing revision of the plan will review the new information and develop a strategy for the conservation and restoration of Sacramento-San Joaquin Delta native fishes through the identification of recovery actions that specifically address the threats to their existence. Species covered by this plan are delta smelt, longfin smelt, Sacramento splittail, and Sacramento perch.

  The basic goal of the Delta Native Fishes Recovery Plan is to establish self-sustaining populations of the species of concern that will persist indefinitely. A variety of actions may be needed in order to achieve this goal. To be effective, recovery planning must consider not only species or assemblages of species but also habitat components, specifically, their structure, function and change processes. Restoration actions may also include the establishment of genetic refugia for delta smelt. A draft of this recovery plan is expected in mid-2009.

- ***US National Marine Fisheries Service (NMFS) Central Valley Salmonids Recovery Plan.*** The NOAA Fisheries Technical Recovery Team (TRT) has produced four documents on 1) current and historical population distributions of winter- and spring-run Chinook salmon, 2) historical population distribution of Central Valley steelhead, 3) population viability, and 4) research and monitoring needs. These documents provide the foundation for the draft Central Valley Salmonid Recovery Plan (2008). Species addressed in the draft recovery plan include Sacramento River winter-run and Central Valley spring-run Chinook salmon and Central Valley steelhead. NOAA Fisheries is currently circulating for internal review the draft recovery plan that includes a detailed and prioritized threats assessment and a lengthy list of recovery actions responsive to the prioritized threats. The draft Recovery Plan is currently undergoing State and federal co-manager review; it will be released for public review later in 2008.

Central Valley Joint Venture (CVJV) 2006 Implementation Plan

The Central Valley Joint Venture (CVJV) works collaboratively to protect, restore, and enhance wetlands and associated habitats for waterfowl, shorebirds, waterbirds, and riparian songbirds through partnerships among conservation organizations, public agencies, private landowners, and others interested in bird habitat conservation in the Central Valley. The CVJV 2006 Implementation Plan focuses on ecosystem health in reference to wetlands and the values these wetlands provide to the various bird groups. The CVJV 2006 Implementation Plan contains Central Valley-wide objectives for the protection, restoration, and/or enhancement of seasonal and semi-permanent wetlands, riparian areas, rice cropland, and waterfowl-friendly agricultural crops; it also includes basin-specific recommendations for the Delta, the Yolo Basin, and the Suisun Marsh (CVJV 2006).

In accordance with the recommendations within the Implementation Plan, Ducks Unlimited, one of the partners in the CVJV, has completed 46 wetland restoration and protection projects benefiting migratory birds and other wildlife on approximately 20,000 acres in the Delta alone. It is anticipated that such efforts to protect, restore, and enhance wetland and agricultural crops for the benefit of waterfowl and other avian and terrestrial species will continue to enhance ecosystem function and survival of those species. Although the initial focus of the ERP Conservation Strategy will be on actions contributing to recovery of pelagic organisms in the Delta, actions benefiting waterfowl and terrestrial species are consistent with this Conservation Strategy and are expected to be funded by ERP over the longer term.

Regional Habitat Conservation Plans (HCPs)

There are a number of HCPs that are in different stages of completion and development for the five main Delta counties:

- ***South Sacramento County HCP***. This HCP is under development for the protection of vernal pool and upland habitats that are being quickly diminished by vineyards and housing, and of several special status terrestrial species including Swainson's hawk and burrowing owl. The geographic scope of this HCP expressly excludes the Sacramento-San Joaquin Delta portions of Sacramento County (the westernmost boundary is Interstate 5). Aquatic species are not being addressed by this HCP, and have historically been covered by Army Corps 404 permits and DFG Streambed Alteration Agreements. Sacramento County is currently working with the Army Corps, U.S. Environmental Protection Agency, and DFG in developing programmatic permits which may be incorporated into the HCP. Draft environmental documentation and implementing agreement for this HCP is expected in mid-2009 with all permits in place by the end of 2010.
- ***Eastern Contra Costa County HCP/NCCP.*** This approved HCP/NCCP was developed partially to address indirect and cumulative impacts to terrestrial species from development supported by increases in water supply provided by the Contra Costa Water District. The HCP/NCCP permit areas is primarily outside of the Legal Delta and with the exception of the Dutch Slough/Big Break area, lower Marsh Creek, and lower Kellogg Creek. Investments in land acquisition and habitat improvements are also focused outside of the Legal Delta. Fish species, including salmonids, were not covered in the HCP/NCCP. Impacts to fisheries are addressed through separate consultation and permitting.

- ***Yolo County HCP/NCCP***. This county-wide HCP/NCCP will provide for the conservation of between 70-80 species in five habitat types: wetland, riparian, oak woodland, grassland and agriculture. No aquatic species are being addressed in this HCP; project-specific mitigation will be developed for projects affecting aquatic resources. Draft environmental documentation is expected in late 2008, with permits in place by the end of 2009.
- ***Solano County HCP***. The Solano HCP is under development to address species conservation in conjunction with urban development and flood control/infrastructure improvement activities. Covered species will include federally- and State-listed fish species and other species of concern. The geographic scope includes lands within the Legal Delta. Draft environmental documentation is expected in late 2008/early 2009, with permits in place by the end of 2009.
- ***San Joaquin County Multi-Species Conservation Plan (SJMSCP).*** This approved plan was developed to provide guidelines for converting open space to other land uses, preserving agriculture, and protecting species. The geographic scope includes lands within the Legal Delta.

* Appendix B contains a listing of the species covered by each of these plans.

Guiding Principles

In testimony before the Delta Vision Blue Ribbon Task Force, Dr. Mike Healey, the Lead Scientist for the CALFED Program, identified several ecological design principles for a sustainable ecosystem in light of the dramatic unavoidable changes the present ecosystem will likely experience. He noted the challenge in developing actions toward a sustainable Delta is "to manage the consequences of change so that the Delta continues to deliver a broad spectrum of market and non-market services – but not necessarily the same services as today" (Healey 2007). The ecological design principles outlined are intended to help guide the development of actions toward an ecosystem that is healthy enough to accommodate a variety of market and non-market ecological services to enrich human economy and society.

In addition, in a presentation before the BDCP Steering Committee in October 2007, Dr. Denise Reed, the lead Independent Science Advisor for BDCP, identified a number of principles for conservation planning in the Delta and Suisun Marsh (Reed 2007). The design principles presented by Dr. Healey and the conservation principles presented by Dr. Reed are in some ways complementary, and will guide development of the ERP Conservation Strategy.

Components

The ERP Implementing Agencies will incorporate the following components in their development of a robust conservation strategy:

  - Targets for metrics representing conservation goals should be established. In some cases, a surrogate indicator, or suites of related metrics representing conservation goals, will be needed to measure more completely the progress towards established targets. For example, a target defining the goal of achieving a "viable population" need not be limited to a number of individuals, but can include range, genetic diversity, access to population refugia (sustenance of metapopulations), etc.

- All factors influencing conservation goals, such as for species populations, habitats, and ecological processes, should be identified within the strategy.

- The best available science will be used adaptively to keep the conservation strategy relevant and responsive over time.

- A clear roadmap to achieving conservation goals, such as species recovery, should be transparently documented and justified via a rational, analytical framework.

- An analytical framework to generate a comprehensive suite of actions tailored to meet conservation goals, which ideally are explicitly quantitative.

- Monitoring and performance measures will be integral to project design.

- Provide sufficient flexibility to allow for potential unforeseen or significant unpredicted events.

- Clearly identify areas of uncertainty, with quantification, where possible.

- Develop criteria for prioritizing actions based on sound conservation principles.

As new information is developed or becomes available, the strategy will update and augment current ERP guidance through explicit re-evaluations of goals and objectives and potential restoration actions in light of present-day conditions and available information. This will include development of quantitative targets, performance montoring protocols and a prioritization strategy. The ERP Implementing Agencies believe this strategy framework and ensuing strategy development process will continue to provide a more focused and coherent systematic approach to realize fundamental ERP goals.

ERP Conservation Strategy for Stage 2, Delta and Suisun Planning Area

The ERP Conservation Strategy planning area includes the Sacramento-San Joaquin Delta Ecological Management Zone (EMZ) and Suisun Bay and Marsh Ecological Management Unit (EMU) of the Suisun Marsh/North San Francisco Bay EMZ, as described in ERPP Volume II (CALFED 2000b) and accompanying ERP Maps (CALFED 2000h). Focus on this area for the near term is in response to indications that CALFED's through-Delta conveyance alternative has not achieved sufficient progress toward ecosystem restoration and issues regarding levee security, water supply reliability, climate change, and sustainability of the Delta.

Many of these issues are being analyzed in other planning initiatives in the Delta and Suisun Marsh as described above. To help provide guidance for these activities, an updated ERP biological vision and conservation strategy for the Delta and Suisun planning area is needed that reflects changing knowledge, conditions, and understanding of the system. It is intended that this strategy be more explicit about the types and locations of actions needed to meet the goals and objectives in the Strategic Plan.

It is anticipated that ERP implementation during Stage 2 (2008-2030) will be broken down into two "Phases". Phase 1 would run from present day through approximately 2020 (this is the anticipated timeline during which Delta conveyance of freshwater around or through the Delta will have been resolved and alternative conveyance systems constructed, and will also allow for initial analysis of how a new conveyance system is performing in relation to through-Delta conveyance). Phase 2 would run from ~2020 to 2030, the year in which the CALFED 30-year program (and the ERP which is a component of this program) is expected to be complete. If, after 2030, it is determined that ERP implementation by State and federal fish and wildlife agencies is successful proceeding toward its goals and objectives for ecosystem restoration, the program could be extended beyond 2030, and all appropriate environmental documentation or agreements to extend the ERP would be pursued during Phase 2.

Delta and Suisun Planning Area

For the purposes of this conservation strategy, the statutory Sacramento-San Joaquin Delta (Water Code Section 12220 et seq.) and Suisun Marsh (Public Resources Code Section 29101 et seq.) comprise the planning area, based on similar ecosystem components and functions. The Delta and Suisun Planning Area is the same as the ERPP-defined areas of the Sacramento-San Joaquin Delta EMZ and the Suisun Bay and Marsh EMU of the Suisun Marsh/North San Francisco Bay EMZ, respectively (CALFED 2000h). Descriptions of existing conditions in the Delta and Suisun Marsh were derived from ERPP Volume II: Ecological Management Zone Visions (CALFED 2000b) unless otherwise noted.

In developing the Stage 2 Conservation Strategy for the Planning Area, a primary consideration is whether ecosystem restoration can be achieved with existing water export facilities and their operations, or whether alternative water conveyance systems are necessary to achieve restoration goals and objectives and meet recovery goals. One of the main constraints to re-establishing natural physical and biological processes has been management of water supplies to maintain the Delta as essentially a freshwater body over the last several decades. Alternative conveyance options are currently being evaluated by CALFED and through the BDCP, DRMS and Delta Vision planning processes in light of recent concerns over the POD crisis, unreliability of water supplies, levee vulnerability, and climate change scenarios. These options are currently being evaluated through modeling studies and environmental documentation that may ultimately result in the construction and operation of new facilities, such as an isolated facility to convey water around the Delta. The conservation strategy will evolve as more information on ecological relationships and restoration potential emerges from studies of water conveyance alternatives.

As noted previously, planning for restoration of the Suisun Marsh EMU is being undertaken by the Charter entities responsible for developing the Suisun Marsh Plan. The goals of the Suisun

Marsh Plan are consistent with this larger ERP conservation strategy; thus, any early restoration efforts within the Suisun Marsh will proceed in accordance with the Suisun Marsh Plan.

The Sacramento-San Joaquin Delta

Once a vast maze of interconnected wetlands, ponds, sloughs, channels, marshes, and extensive riparian strips, the Delta now consists of islands of reclaimed farmland protected from flooding by hundreds of miles of levees. Remnants of the tule marshes are found on small channel islands or shorelines of remaining sloughs and channels. Land elevations in the Delta generally range from 25 feet below to 10 feet above mean sea level. Lower elevations are generally found in the central part of the Delta with higher elevations found on the periphery. Elevation is an important factor in evaluating the quality of habitats and in designing habitat restoration projects.

Hydraulic processes in the Delta are influenced by tides, river inflow, weather, channel diversions, upstream water releases and diversions, and temporary and permanent rock barriers. Freshwater inflow and tidal exchange transports sediments, nutrients, organisms and energy. These factors influence natural successional processes in the Delta. Hydraulic processes have been modified in the Delta since the mid-1800s, largely coinciding with the Gold Rush (e.g. transport of sediment and debris from upstream gold mining activities) and the initiation of farming on some Delta lands by settlers (DWR 1993). Reclamation of Delta lands for agriculture continued from the late 1800s through the early 1900s (the last island, McCormack-Williamson Tract, was reclaimed in 1934) (Lund et al. 2007). Reclamation of Delta lands significantly reduced the extent of tidal marsh in the Delta and served to disconnect land areas from their historic interface with rivers and channels. Compounding this problem, the inflow of freshwater to the Delta began diminishing with the development of water storage and conveyance projects to supply urban and agricultural users in the upstream Sacramento and San Joaquin River watersheds. Reductions in flow into the Delta from the Mokelumne River began in the late 1800s with construction of a project to provide fresh water to the East Bay. Deliveries from Rock Slough into the Contra Costa Canal began in 1942.

The federal Central Valley Project (CVP) was authorized in 1933; the construction some of its primary components, Friant Dam on the San Joaquin River and Shasta Dam on the Sacramento River, were completed in 1942 and 1944, respectively. Two other CVP facilities, the Delta Mendota Canal (designed to export fresh water from the Delta to agricultural areas in the San Joaquin Valley) and the Delta Cross Channel (designed to increase the flow of Sacramento River water into the central Delta and toward the new Delta-Mendota Canal pumps in the south Delta), began operating in 1951. In 1960, California voters approved the first phase of expenditures for the State Water Project (SWP), designed to supply fresh water from northern watersheds to cities and agricultural users in southern California that were beyond the reach of the CVP. Construction of storage and conveyance components of the SWP served to further limit the amount of fresh water entering the Delta from its tributaries, and initiation of exports into the SWP's California Aqueduct in the 1960s exacerbated the impacts of water exports on the Delta's natural resources (DWR 1993, Lund et al. 2007). Data collected since 1930 shows that, when comparing the averages of 20-year periods since CVP was authorized in the 1930s, in-Delta uses (including diversions to Contra Costa Canal and the North Bay Aqueduct) have remained constant at 4-5% of total flows, while upstream uses have increased from 14% to 31% of total flows, exports of water have increased from none to 17% of total flows, and outflows to the ocean have decreased from 81% to 48% of total flows (Figure 3) (Blue Ribbon Task Force, 2007).

Current hydraulic conditions in the Delta reduce the ability to provide suitable residence times and more natural net flows; to provide adequate transport flows to the central and west Delta and the low salinity zone; and to support high quality rearing and spawning habitat, nutrient cycling, and foodweb integrity.

Important aquatic habitats are severely limited by levees and flood control systems. Existing aquatic habitats in the Delta include shaded riverine aquatic (SRA) habitat, vegetated and non-vegetated shallow shoal areas, open-ended sloughs, and small dead-end sloughs. The large, open river channels of the Sacramento and San Joaquin rivers in the central and western Delta are more like tidal embayments of Suisun Bay to the west of the Delta. Areas with SRA and shallow shoal habitat areas are small and fragmented and are subject to excessive water velocities and periodic dredging that degrade or scour them. ERP has provided funding for a number of projects that utilized bioengineering techniques to protect levees and in-channel islands during Stage 1; these practices could be expanded via continued outreach to local resource conservation districts, and possibly enhanced to provide riparian vegetation on levees and associated shaded riverine aquatic habitat. Although in 2007 the U.S. Army Corps of Engineers adopted a policy banning vegetation on project levees, due to the significant habitat impacts that would occur from complying with this policy in California, the Corps is allowing the State to develop a framework that would allow retention of vegetation on levees while remaining in "active" status in the PL 84-99 program; the Corps should approve this framework by September 2008.

The Delta is characterized primarily by agriculture with a mosaic of smaller natural habitats that support the system's fish, wildlife, and plants. Instream and surrounding topographic features influence ecological processes and functions and are major determinants of aquatic community potential. Both quality and quantity of available habitat affect structure and composition of the Delta's biological communities. Most of the remaining natural habitats consist of small, scattered and degraded parcels.

Less than five percent of the Delta consists of riparian, oak woodland, fresh emergent wetland, and seasonal wetland habitats. Much of the remaining riparian and wetland habitat is found in the north Delta, with small remnant patches throughout the rest of the Delta.

Suisun Marsh and Bay

The Suisun Marsh and Bay EMU is adjacent to and west of the Sacramento-San Joaquin Delta EMZ, between the Delta and San Francisco Bay in southern Solano County. The predominant habitat types in this unit are tidal perennial aquatic habitat, tidal wetland, seasonal nontidal (managed) wetland, seasonal brackish managed marsh, and grassland. Suisun Marsh contains about 10 percent of the remaining natural wetlands in the State and is the largest brackish marsh remaining on the west coast of North America. The marsh is primarily a managed wetland, with levees to control water level and seasonal flooding with fresh water to balance soil salinities.

Historically, the eastern portion of Suisun Marsh was predominantly tidal fresh and seasonally brackish water marsh. The western portion of the marsh was predominately fresh and brackish marshland with more saline marsh existing on the western edge. Within these broad marshes were sloughs, channels, ponds, and small bays. Except for parts of Suisun Bay, the segment had relatively few tidal flats. Large areas of moist grasslands connected the baylands with upland areas.

As a result of the federal and state legislation encouraging the reclamation of "swamp lands," the marsh was engineered so that it is now surrounded and transected by a complex of levees. Reclamation actions reduced tidal marsh and tidal flat habitats from 68,000 acres in the 1800s to about 15,000 acres presently. Some areas were leached to remove salts and were farmed for crops, but the majority of the reclaimed areas were used as pasture for cattle and flooded seasonally for waterfowl hunting. This flooding regime gradually favored vegetation that displaces the native salt grass and pickleweed. The largest intact undiked wetlands remaining in Suisun Marsh are associated with Cutoff Slough and Hill Slough in north central Suisun Marsh.

An extensive network of sloughs conveys tidal flows and some freshwater flow into the marsh. Montezuma Slough, the largest of these, is connected to Suisun Bay at its eastern and western ends. The slough is an important nursery area for many fish, including Chinook salmon, striped bass, splittail, and delta smelt. The Suisun Marsh Salinity Control Structure was constructed near the eastern slough entrance and began operation in the fall of 1988 to limit the tidal influx of saltwater from the Bay into Suisun Marsh. The salinity control structure operates from September through May by closing during flood tides and opening during ebb tides to keep salinity in the slough low throughout the managed wetland flooding season. When the gates are being operated, routing more fresh Sacramento River water into Montezuma Slough results in the saline water in Suisun Bay intruding farther to the east, and can contribute to increasing salinity levels in the western Delta (IEP 2008; Gartrell, pers. comm.).

Restoration of Critical Ecological Processes and Habitats

Consistent with current conservation biology science and practices, the intent of the conservation strategy for the Delta and Suisun Planning Area is to take an ecosystem-based approach to the recovery of native and threatened and endangered species, rather than a piecemeal species-by-species approach. This ecosystem-level approach requires a focus on the restoration of critical ecosystem processes, as these important processes will help determine the type, extent, and quality of the different habitat types within the Planning Area, and in turn, facilitate analysis of how these species may benefit from those habitats. The conservation strategy will also address the reduction or elimination of stressors that impact ecosystem processes, habitats, and species. These actions are cumulatively expected to aid in the recovery of numerous species in the planning area.

Ecological Processes

The ERPP identifies key ecological processes in the Delta and Suisun Planning Area. Of particular note are processes relating to hydrology and aquatic foodweb dynamics.

Hydrology

Freshwater Flow

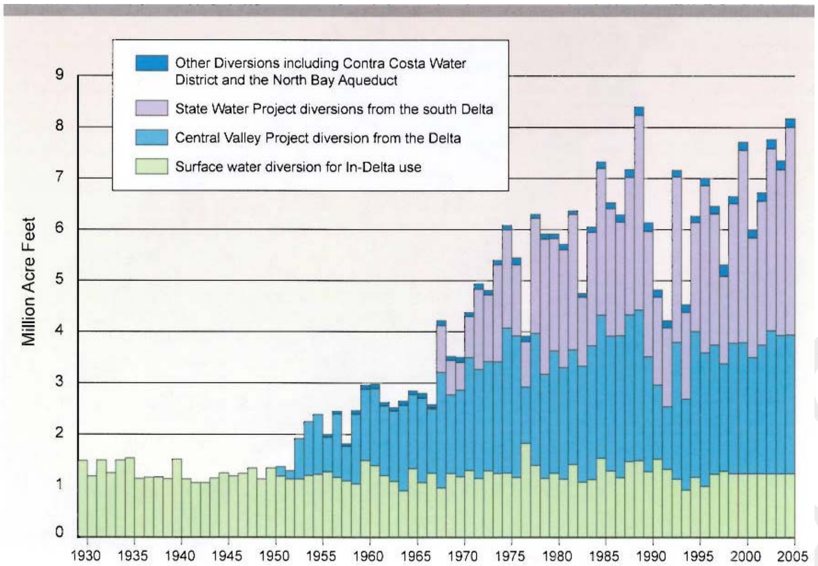
In general, theory and experience show that the more water left in the system (i.e., that which flows through the Delta into Suisun Bay and eventually the ocean), the greater the health of the estuary overall; there is no such thing as "too much water" for the environment (Healey 2007). High river discharge has been linked to greater abundance of harvested species in other estuaries (Healey 2007).

Positive relationships between historical flows and fish abundance or survival have been documented in the Bay-Delta estuary (e.g. for Chinook salmon, striped bass, and longfin smelt). The ecological indicator X2, the location of the 2 ppt (2.64 mmhos/cm EC) isohaline in kilometers upstream from the Golden Gate, is related to outflow, and pelagic habitat quality in the estuary can be characterized by changes in X2 (i.e. abundance of numerous species increases in years of high outflow, when X2 is pushed seaward) (Jassby et al. 1995, IEP 2008). Based on correlations with the health of several Delta aquatic species, requirements for X2 in the winter and spring months are contained in the State Water Resources Control Board (SWRCB) Bay-Delta Water Quality Control Plan. Net flow (i.e. adjusted for tides) in the lower San Joaquin River in the western Delta (Qwest) has been used in Biological Opinions in the past to define conditions acceptable for juvenile Chinook salmon and may also be pertinent to delta smelt and other species (NMFS 1993). The importance of flow in the Sacramento River at Rio Vista as a cue for adult Chinook salmon migration has been documented (Stein 2004) and the SWRCB Bay-Delta Water Quality Control Plan contains an objective for flow at Rio Vista. Flow in both the Sacramento and San Joaquin has been identified as an important factor for juvenile Chinook salmon survival during emigration from these basins (Newman and Rice 2002, Newman 2003, Newman 2008). Recent analyses suggest a strong statistical correlation between water exports/San Joaquin River flow and fish salvage/entrainment at the export pumps. Net reverse flow in Old and Middle Rivers (OMR) in winter months, a function of San Joaquin River flow into the Delta, export pumping rate and tides, is correlated with salvage of adult delta smelt (Pete Smith, USGS ret. unpublished) and has been recently used as a method to minimize water project effects. Other modeling studies demonstrate a probable effect of net upstream flows on free-floating delta smelt larvae, leading to use of constraint on OMR flow to minimize impacts on larvae and juvenile delta smelt. OMR requirements are included in the recently-issued Final Interim Remedies Order to Protect Delta Smelt (Wanger interim order in *NRDC et al v. Kempthorne*, 2007), and are expected to be incorporated by the U.S. Fish and Wildlife Service in a new CVP OCAP biological opinion for delta smelt.

It appears that relationships between Delta outflow/X2 and fish abundance have shifted in recent years, with lower abundance/production associated with any given flow/X2 condition (Figure 4) (IEP 2008.). Several pelagic fish species have experienced a precipitous decline in 2000-2007, despite at least moderate Delta outflows in some recent years. These outcomes do not negate the importance of flow, but rather suggest that other factors (such as the invasion of *Corbula* into the estuary in 1986) in addition to flow may be having an increasingly important influence on ecosystem function.

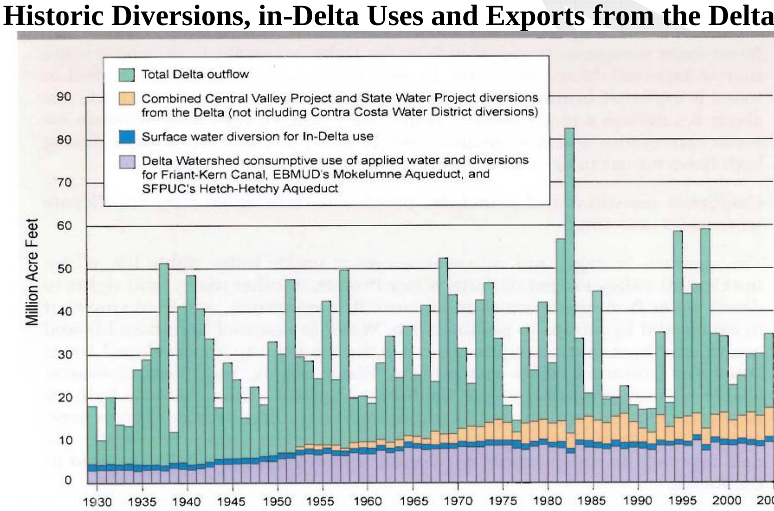
Figure 3

Historic Diversions from within the Delta



Source: measured, calculated and modeled data from an array of sources as compiled by Tully & Young, Inc. with data and assistance from DWR, the Bay Institute and the State Water Contractors.

Historic Diversions, in-Delta Uses and Exports from the Delta, plus Outflows



Trends in Destinations and Uses

Period	Average Annual Total (MAF)	Outflow	In-Delta	Exports	Delta Watershed
1930 to 1949	25.80	81%	5%	0%	14%
1950 to 1969	31.71	67%	4%	4%	24%
1970 to 1989	34.34	51%	5%	15%	29%
1990 to 2005	32.85	48%	4%	17%	31%

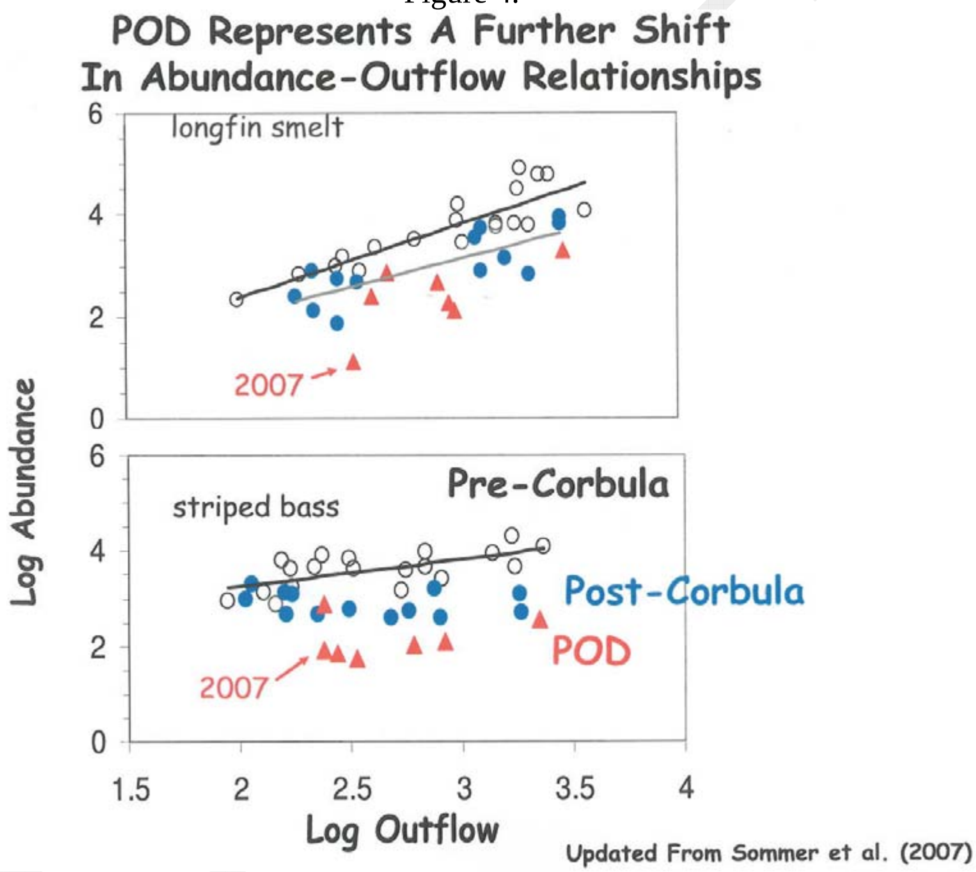
When the averages of 20-year periods are compared, these data show:

- Outflows to the ocean go down from 81% to 48% of total flows;
- In-Delta uses are essentially constant at 4% to 5% of total flows;
- Exports of water taken in the Delta but conveyed elsewhere go up, from none to 17% of total flows; and
- In-Delta watershed (before reaching Delta) uses also go up, from 14% to 31% of total flows (some of these are exported from the Delta watershed).

Source: measured, calculated and modeled from an array of data sources as compiled by Tully and Young, Inc.

Because substantial changes in the Delta environment have occurred over an extended period of time including the recent past, it is difficult to identify a set of specific minimum flow requirements for the Delta ecosystem and guarantee the sufficiency of such flows for recovery and sustainability of the Delta's aquatic species and food web production. Basin-specific inflows, Delta outflow/X2, and internal Delta hydrodynamic parameters (net Old River and Middle River flow, Qwest, Rio Vista flow) are among the characteristics of the Delta ecosystem that may need to be defined.

Figure 4.



Source: Sommer, 2008. PowerPoint presentation to State Water Resources Control Board, see notes.

Hydrologic models for the Delta have been or are being developed by several planning efforts. DRERIP conceptual models are expected to yield qualitative information on how flows affect critical ecosystem processes, habitat restoration, stressors, and species in the Delta; many of these models have been peer reviewed and approved for broad use in evaluating ecosystem restoration actions, and the remainder should be complete by fall of 2008. The numerical model developed by the DRMS study is evaluating how future climate conditions may affect flows, to address risks to Delta levees and other infrastructure. Once completed and available for wider use, these models should be useful to predict the future availability of freshwater to the Delta and demonstrate the importance of flows to the health of the estuary; however, at this time, the recommendation for a minimum flow regime to sustain the health of the estuary is based on a combination of historical relationships and professional judgment.

The desired pattern of freshwater westerly flow through the Delta would more closely emulate the natural hydrograph than the current flow patterns. This may include a fall or early winter pulse that emulates the first "winter" rain and elevated late winter and spring flows. The aim of these improved flows would be to provide attraction flows for anadromous and migratory fish moving upstream, improve survival of juvenile Chinook salmon rearing in the Delta, and provide downstream passage for fish moving through the Delta. In conjunction with improved channel configuration to a more dendritic system that connects channels to marshes and increases residence time, these flows could improve productivity and transport of food produced in the Delta to downstream areas in the western Delta and Suisun Bay. Improved flows could also reduce the potential toxic effects of contaminants released into Delta waters through dilution, transport sediment, and promote growth of riparian vegetation. These improved flows are particularly important in normal and dry years.

Environmental Water Quality

In addition to the desired amounts and directional freshwater flow patterns that would benefit native aquatic species in the Delta, there are several physical and chemical parameters of water quality that must be considered. These include salinity, turbidity, water temperatures, dissolved oxygen, pH, and organic carbon. Other constituents (contaminants and heavy metals) are also important components of water quality, because they can have negative impacts on native aquatic species. These harmful constituents are discussed in more detail in the context of stressors, later in the document.

<u>Salinity.</u> Salinity is the primary water quality constituent affecting the distribution of fish in the estuary (Nobriga 2008, see notes). Fall salinity has been relatively high since 2000, with X2 positioned further upstream; this decrease in fall habitat quality for delta smelt in particular could be significant, as the individuals present in the system at this time are pre-spawning adults (Feyrer et al. 2007). Initial results from recent IEP studies have also identified increased duration in the closure of the Delta Cross Channel, operations of Suisun Marsh salinity gates, and changes in export/inflow ratios (i.e. Delta exports/reservoir releases) as contributing factors (IEP 2008).

Episodes of periodic salinity intrusion and a more heterogeneous environment in the Delta have been recently proposed as important processes to be restored in the Delta (Lund et al. 2007, Nobriga 2007). Continuous heterogeneous environments are better able to absorb stochastic perturbations and provide a variety of habitat types for fish and wildlife (van Nes and Scheffer 2005). Greater variability in environmental conditions in the Delta might provide a competitive advantage for desired estuarine fishes over non-native invasive species (Lund et al. 2007, Nobriga 2007). Salinity fluctuations in the Delta may also help to control invasive organisms such as *Egeria densa* and largemouth bass.

Turbidity There has been recent information presented in numerous forums that juvenile and adult delta smelt distribution is strongly associated with turbid water, and that turbidity serves as an environmental trigger for upstream migration of delta smelt and longfin smelt. In addition, turbidity reduces predation risk to migrating Chinook salmon in other estuaries (e.g. Fraser River) (Nobriga 2008, see notes). It is hypothesized that higher flows during summer will increase the extent of low-salinity, higher-turbidity habitat for delta smelt, and that removal of aquatic plants that trap sediments would also enhance turbidity and increase the extent of habitat for delta smelt (DSWG 2006). The importance of turbidity to native species (in addition to delta smelt) will be further evaluated in terms of the habitat heterogeneity that it is desirable to achieve as part of the conservation strategy for the planning area.

Water temperatures, dissolved oxygen, pH, and dissolved organic carbon.
The ERP includes targets for Central Valley stream temperatures, including maintaining specified water temperatures in salmon and steelhead spawning, summering, and migration areas during certain times of the year (CALFED 2000a). Maintenance of stream temperatures upstream of the Delta are important not only in terms of individual species' tolerances, but also because temperature drives metabolic and primary production rates and can influence mobilization rates of toxics and nutrients (e.g. development of toxic algal blooms from cyanobacteria *Microcystis aeruginosa*) (Swanson 2008, see notes). While riparian habitat (including both riparian forest and shaded riverine aquatic areas) may help to lower water temperatures in the tributaries to the Delta, the Delta and Suisun channels temperatures are driven primarily by environmental factors (e.g. air temperature). Areas of riparian habitat consisting of at least 50-100 acres could create sufficient air convection currents to cool adjacent waters (ERP 2000a). Small streams have been shown to experience a reduction in water temperatures of up to ~ 4° C immediately downstream of 40-70% step changes in riparian vegetation shade (Rutherford et al. 2004); direct shading of smaller channels in the planning area may likewise reduce water temperatures. Extensive riparian habitat was historically located in the north Delta, specifically along the Sacramento River and Elk and Sutter Sloughs (TBI 1998).

Most aquatic life is dependent upon sufficient levels of gaseous oxygen dissolved in water, or dissolved oxygen (DO); the optimum range of DO for fish and aquatic life is 5-9 mg/L (DFG 2008b). When DO levels drop below this range, fish behaviors such as feeding, migration, and reproduction can be negatively affected for some species. DO levels approaching 2 mg/L yield hypoxic conditions, which serve as a barrier to fish migration and can negatively impact food web organisms (DFG 2008b). Factors that can lead to low DO conditions in isolation or in tandem include high water temperatures, insufficient water flow and/or circulation to sustain adequate aeration in channels, high loads of ammonia, and high levels of algal production from within the planning area as well as transported from upstream areas (DFG 2008b). Low DO is a problem in the lower San Joaquin River at the Stockton Deep Water Ship Channel and occasionally in the Suisun Marsh. Low DO is discussed further in the "Stressors – Water Quality" section.

pH is an important component of environmental water quality because of its prevalent role in the speciation of metals. For example, fish in low-alkalinity environments (pH of less than 6.0-6.5) often have higher body or tissue burdens of mercury, cadmium, and lead than do fish in nearby environments with higher pH levels (Werner et al. 2008). Peat soils within the planning area could exacerbate acidic conditions.

Finally, dissolved organic carbon is an important nutrient source for microbes and algae that form the base of the aquatic food web. Its importance is described in the "Aquatic Food Web" section.

As described below, improvements in freshwater flows and water quality conditions, channel hydraulics, and floodplain inundation would lead to a more productive aquatic foodweb by increasing residence time and providing more nutrient inputs into the Delta. These processes, in conjunction with a substantial increase in tidal wetlands could increase primary and secondary productivity in the Delta (Jassby and Cloern 2000). Connectivity between tidal marshes and Delta channels and sloughs is important to facilitate transport of food and organisms throughout the system (Cloern 2007).

Aquatic Foodweb Dynamics

Primary and secondary productivity in the Delta has declined dramatically over the past 30 years (Jassby et al. 2002). This decline intensified with the introduction of the overbite clam (*Corbula amurensis*) in the mid-1980s (Kimmerer et al. 1994), but had been ongoing prior to the introduction. *Corbula* has a significant impact on the pelagic foodweb of the low salinity zone in Suisun Bay and the western Delta by consuming both primary (phytoplankton) and secondary (copepods) producers (Kimmerer and Orsi 1996). Actions in this conservation strategy aim to restore primary and secondary production to levels comparable to those during the 1960s and early 1970s by enhancing productivity through the restoration of suitable hydrologic conditions and habitats in the Delta, and by reducing loss of productivity to introduced aquatic species and water exports from the system.

Due largely to inputs from urban and agricultural sources, there is generally high nutrient availability in the Delta. The Delta is therefore rarely nutrient-limited (Jassby et al. 2002). The concentrations of dissolved organic carbon (DOC) are also quite high throughout the Delta. This form of carbon, however, is less bioavailable than the larger particulate organic carbon (POC) and does not efficiently enter the pelagic foodweb because it must first be converted by bacteria (Sobczak et al. 2002, Sobczak et al. 2005). POC occurs at lower concentrations than DOC. Of the POC available in the Delta, phytoplankton-derived carbon is strongly correlated to bioavailability (Sobczak et al. 2002) and supports higher growth rates in zooplankton (Müller-Solger et al. 2002).

Although phytoplankton production (as measured by chlorophyll *a* concentration) makes up a small portion of the system's organic matter, it has been shown to form the base of the pelagic foodweb in the Delta (Jassby and Cloern 2000, Sobczak et al. 2002), and therefore a decline in this form of primary productivity likely translates up the foodweb. In fact, copepods, which feed on phytoplankton and are a valuable food source for Delta fishes, have been shown to be food-limited in the Delta (Kimmerer and Orsi 1996, Müller-Solger et al. 2002, Sobczak et al. 2002). The general conclusion from nearly all studies of food limitation is that growth or reproductive rate is severely food-limited most of the time (DFG 2007).

Although *Corbula* has had a documented impact on the foodweb of the San Francisco Bay estuary, this is likely not the only cause of low productivity. At relatively low concentrations, ammonium (NH_4) has been shown to inhibit uptake of nitrate (NO_3) by phytoplankton in the bay (Wilkerson et al. 2006, Dugdale et al. 2007). Spring phytoplankton blooms occur only when NH_4 concentrations are less than 4 μmol L^{-1} (Wilkerson et al. 2006, Dugdale et al. 2007), allowing uptake of the more abundant NO_3. Once the NO_3 in the system is available to phytoplankton, growth is rapid and can continue until the relatively large amount of NO_3 is consumed. This requires favorable conditions (stratification events and solar radiation) of sufficient duration for phytoplankton to uptake the inhibitory NH_4 to a point when the concentration drops to less than 4 μmol L^{-1}. At these low concentrations, the inhibitory nature of NH_4 is relieved and blooms fueled by NO_3 can occur. Phytoplankton blooms typically occur following high spring flow events, when NH_4 in the system is diluted and stratification reduces light limitation (Cloern 1991). The stratification must be maintained long enough for phytoplankton to further reduce the concentration of NH_4, making the NO_3 available for uptake. The large diatoms produced in the spring bloom forms the food base for the pelagic food web. During a high spring bloom, diatoms can temporarily out produce clam grazing in the Suisun, San Pablo, and Central bays (Wilkerson et al. 2006). A bloom in Suisun Bay occurred only once over the four springs from 2000 to 2003 due to stratification events of insufficient length to overcome the high NH_4 concentrations.

Restoration actions that improve Delta primary production would help to increase zooplankton production and augment the pelagic foodweb. Actions could include increasing water residence times to allow for phytoplankton accumulation, reducing inputs of NH_4 into the system by improving treatment and wastewater treatment plants, and restoring large tracts of tidal marsh to increase rates of nitrification for removal of NH_4 from the system (see tidal marsh section below).

The extensive changes that have occurred in the aquatic environment of the Bay-Delta system have substantially changed the structure of the food webs in both the Delta and Suisun Bay. In terms of energy creation and retention, the freshwater food web structure in the Delta is now "shorter" than the longer, more complicated brackish food web structure in the Suisun Marsh; thus, the freshwater food web may be more important for native species (Kimmerer 2008, see notes).

Potential Activities during Phase 1 in the Delta and Suisun Planning Area (more detail available in Appendix E):

Natural Flow Regimes

- Extension of TNC's Ecological Flows Tool (developed for the Sacramento River) to the Delta
- "Variable Delta" hypothesis on localized scale – (ties in with non-natives): see if manipulation of DO, salinity, flows, and temps can help control SAV on localized scale, as well as how species use or avoid these conditions.
- As part of a comprehensive monitoring program for the Delta, improve monitoring of in-Delta hydrodynamics and fish assemblage response to generate accurate numerical models.
- Determine how downstream channels and habitats have adjusted to post-dam flow regimes and how re-invigoration of riverine processes upstream will affect this habitat.

X2 Relationships

- Develop a way to have unimpaired flows rule decisions on X2, project operations, etc.

- Continue to study the developing evidence in support of the importance of X2 for a number of estuarine species.
- Investigate whether the mechanism of gravitational circulation (in facilitating upstream movement of bottom-oriented life stages of species that reproduce in the ocean but rear in brackish area of the estuary) accounts for the X2-abundance relationships, by increasing the rate of travel to nursery habitat and decreasing distance to it (reducing mortality during migration and increasing the number of young reaching the nursery habitat at higher flows).
- Determine X2 mechanisms for species for which such mechanisms have not yet been identified.
- Determine the importance of X2 in the fall, as well as spring, for some species.

Decline in Productivity/Aquatic Food Web

- Continue to study the roles of non-native species (e.g. Corbula) versus contaminant toxicity in the potential declines in food availability for aquatic species
- Continue to study tidal marsh restoration efforts in the Delta and Suisun Marsh to determine whether this restoration improves system productivity
- Potential impacts of ammonia on primary productivity (studies underway by State and Regional Water Quality Control Boards)

Delta Habitats

Development of the ERP Conservation Strategy Map

The ERP conservation strategy identifies restoration opportunities within the Delta and Suisun Planning Area primarily based on land elevations with consideration of current urban land use constraints (Figure 5), without regard to existing land use, infrastructure, or other constraints at these locations. This is a preliminary view of how the Delta could be configured to restore historic form and function to the maximum extent. Implementation will incorporate historical conditions, soils maps, climate change predictions, infrastructure and development, and water conveyance, in the process of identifying areas where restoration activities should and can be focused. For purposes of this strategy, several broad habitat types have been identified for restoration. These habitat types include intertidal, floodplain, shallow subtidal/open water, uplands, a grassland/vernal pool transition corridor, and subsided lands. Appendix C provides a crosswalk between habitat categories in the ERP Conservation Strategy for the Delta and Suisun Planning Area and those in the ERP Plan.

Delta aquatic and intertidal habitat quantity and quality is in relation to flow. Delta flows and hydrodynamics are largely influenced by water project operations and channel geomorphology for conveyance. While modifications to the infrastructure such as conveyance facilities and changes in operations might appear, on the surface, to allow greater flexibility to manage water supplies while improving ecological processes and habitat restoration throughout the Delta, it comes with a high level of uncertainty. The capacity of new conveyance and operations has yet to be described. Tools are still in development to improve our understanding of the hydrodynamics and hydrology of the Delta. Furthermore, the relationship between flow, residence time, primary production, and pelagic organisms are just now coming together to help us better understand the current demand and operational impacts on the Delta system. Tools for quantifying the flows required for some specific actions are still under development so will come in future iterations of the strategy.

After incorporating an elevation map of the Delta (DWR 2007), rough contour lines were drawn to identify potential restoration opportunity areas. Ecological rationale for mapping decisions were driven by historical conditions and land elevations with consideration of potential sea level rise and other effects of future climate change.

Following are descriptions of current issues and conditions as they relate to the broad habitat types that have been identified, as well as rationales for why these habitats are expected to yield desirable benefits to pelagic organisms and other species throughout the Delta and Suisun planning area. Accompanying these descriptions and rationales are general recommendations on where restoration of these broad categories of habitats may be implemented, in accordance with present land elevations and expected improvements in ecological processes.

It is important to note that the intent of the Conservation Strategy for the Delta and Suisun Planning Area is to implement ecosystem restoration activities within the planning area through land acquisitions (both fee and easement title) and cooperative agreements with willing sellers only. This policy of voluntary participation maintains the intent of the ERP in implementing its program, and is also consistent with the restoration planning process underway for the Suisun Marsh.

Intertidal Habitats

Intertidal habitat is composed of lands that occur between +1 and +7 feet feet in elevation, depending on which Delta or Suisun EMU is under consideration (see Figure 5). More precise information on tidal range will be obtained when the forthcoming LiDAR data become available and accurate tidal ranges within the Delta are determined. All lands in the intertidal range are assumed to have the ability to support tidal marsh habitats (either saline or freshwater) with associated sloughs, channels, and mudflats. Some areas are capable of supporting fairly large contiguous habitat, and others may support only small patches (e.g. mid-channel islands and shoals). Properly functioning tidal marsh habitats have open water channels (subtidal) with systems of dendritic, progressively lower-order channels (intertidal) that dissect the marsh plain. These diverse communities provide structure and processes that benefit both aquatic and terrestrial species. Fairly large areas of tidal marsh habitat are required in order to accommodate high-order channel features. Tidal marsh habitat in the Delta once totaled approximately 350,000 acres (Atwater and Belknap 1980), but today consists of only a few thousand acres (TBI 1998). Suisun Marsh is that largest brackish marsh on the west coast, with about 15,000 acres of intertidal marsh habitat remaining.

Tidal marshes across much of the Atlantic and Gulf coasts of the US, substantial studies have shown that marshes are critical to native fish (Boesch and Turner 1984, Baltz et al. 1993, Kneib 1997, Kruczynski and Ruth 1997, many others). Tidal marshes have been documented to increase foraging success by fish and to provide refuge from predators. On the Pacific coast, studies of southern California and Pacific Northwest tidal marshes have corroborated these

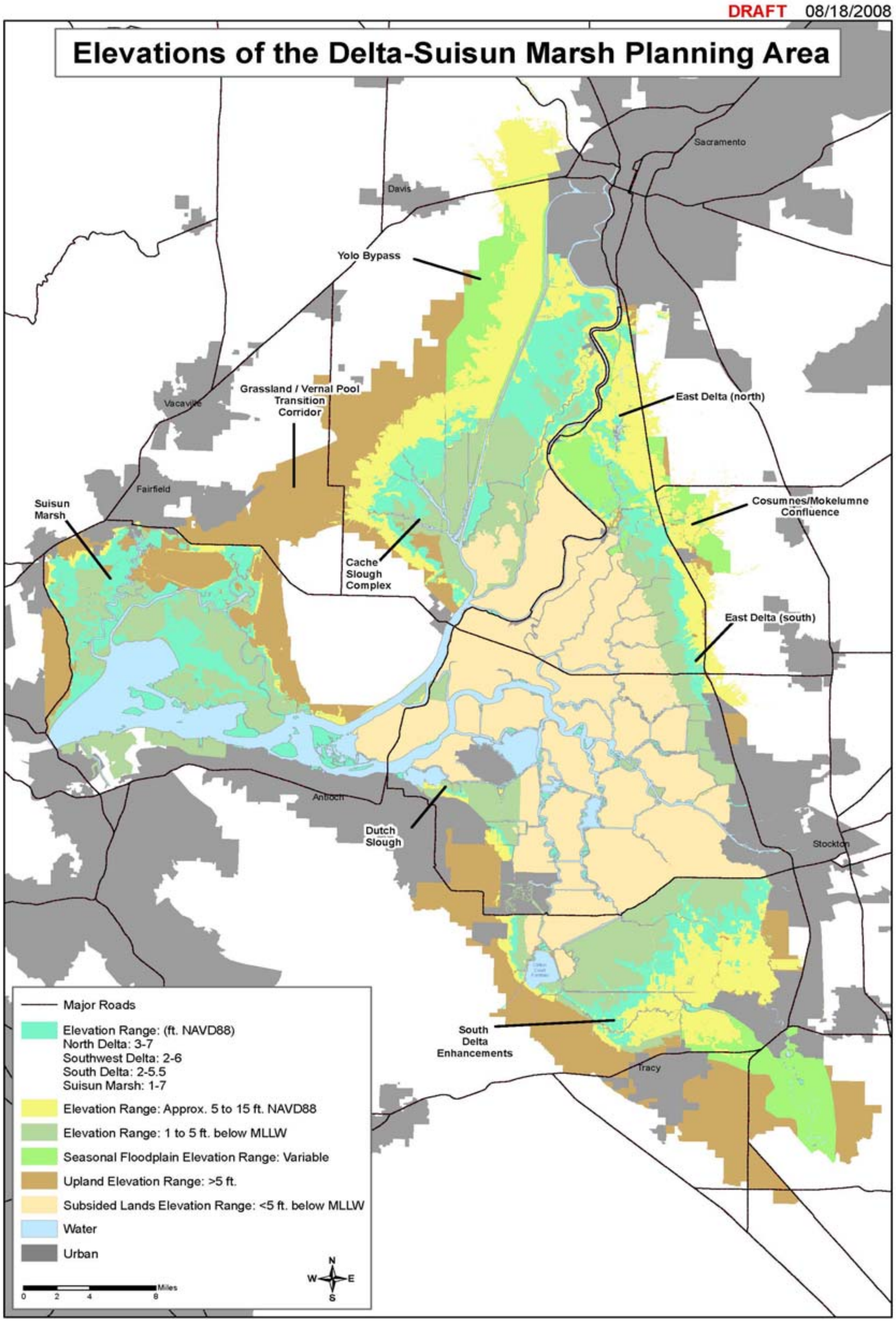


Figure 5: Near-term acquisition and enhancement priorities

results (Healey 1982, Simenstad 1982, West and Zedler 2000, Madon et al. 2001). In the Pacific Northwest, juvenile Chinook salmon occur in tidal marsh habitats when it is available and have improved foraging success and growth rates.

The BREACH studies; http://depts.washington.edu/calfed/breachii.htm), investigated only very small, remnant or restored habitat patches. The lack of larger tidal marsh habitats in the Delta has limited research to these smaller habitat fragments. Nonetheless, these studies do provide interesting results. Although fish sampling was performed at only one reference and three restored sites, relative density of native fish was shown to be higher at the reference marsh (Simenstad et al. 2000). In stomach content analyses, all life stages of chironomids (midges) were shown to be a very important food source for fish in the Delta (both adjacent to tidal marsh habitats and in the open water). Chironomids are associated with marsh habitat, indicating the importance of this habitat.

Chinook salmon fry rear in the Delta, but there is little study of direct habitat use. According to Williams 2006, tagged hatchery fry remained in the Delta up to 64 days and tend to occupy shallow habitats, including tidal wetlands. Stomach contents of salmon rearing in the Delta are dominated by chironomids and amphipods (Williams 2006), suggesting that juvenile salmon are associated with marsh vegetation (Simenstad et al. 2000). There is substantial growth of juvenile salmon in the Delta (Kjelson et al. 1982, Williams 2006).

There has been extensive research on the use of tidal marshes by Chinook salmon in the Pacific Northwest. In many estuaries of the Pacific Northwest, including the Columbia and Fraser river estuaries, Chinook salmon fry usually occupy shallow, near shore habitats including marsh, tidal creeks, and flats, where they feed and grow and adapt to salt water (Healey 1982; Levy and Northcote 1982; Simenstad et al. 1982). They often move far up into tidal wetlands on high tides, and may return to the same channels on several tidal cycles (Levy and Northcote 1982). In estuaries throughout Washington, subyearlings and fry occur mainly in marshes when these habitats are available (Simenstad et al. 1982). Healey (1982) identified freshwater tidal marshes as the most important habitat to juvenile salmon in the Pacific Northwest. In the Columbia River estuary, emergent tidal marsh has been shown to support the greatest abundance of insects and highest stomach fullness scores for juvenile salmon (Lott 2004). As in the Delta, chironomids are the dominant prey item.

In a study of carbon types and bioavailability in the Delta and Suisun, tidal marsh sloughs (in Suisun Bay) had the highest levels of DOC, POC, and phytoplankton-derived carbon (Sobczak et al. 2002). Chlorophyll *a* concentration (a measure of standing crop of phytoplankton) was highest in tidal sloughs and supports the greatest zooplankton growth rate (Müller-Solger et al. 2002) when compared to other habitat types (such as floodplains and river channels). High levels of primary production (as measured by chlorophyll *a*) seen in several regions in the interior of Suisun Marsh is likely due to high residence time of water, nutrient availability, and absence of alien clams (DFG 2007).

Modeling (Jassby et al. 1993) and empirical studies (Lopez et al. 2006) suggest that productivity from high producing areas (such as marsh sloughs) is exported to other habitats. Location of phytoplankton biomass is only weakly correlated with phytoplankton growth rate across several aquatic habitats, therefore other processes (including mixing and transport) are important in determining phytoplankton distribution in the Delta. The data suggests that Suisun Marsh plays a significant role in estuarine productivity by providing an abundant source of primary production and pelagic invertebrates, both of which are significantly depleted in bay and river channel habitats (DFG 2007). Tidal marsh restoration would likely increase phytoplankton biomass in the estuary and enhance the planktonic foodweb.

There is a large input of ammonia (NH_4) into the Delta from agricultural fertilizer runoff, livestock operations, and municipal sewage treatment plant outflows. Ammonia inhibits phytoplankton blooms in Suisun Bay and possibly other open water habitats in the Delta, It therefore lowers overall productivity (Wilkerson et al. 2006, Dugdale et al. 2007, see discussion above in foodweb section). In the absence of actions to reduce inputs of NH_4, tidal marsh restoration may be a promising method of mediating the effects of these inputs. Tidal marsh may increase the likelihood of phytoplankton blooms in the estuary through nitrification and retention of NH_4. In a nutrient-rich estuary, tidal freshwater marsh has the ability to transform or retain up to 40% of NH_4 entering the marsh during a single flood tide. Nitrification accounted for a large portion of the transformation (30%) and nitrification rate in the marsh system was measured at 4-9 times that which occurs in the adjacent water column (Gribsholt et al. 2005). The marsh sediment and biofilm are important sites for nitrification. Tidal marsh may have the ability to improve the base of the food chain in the Delta by increasing primary production in the marsh itself and by increasing the ratio of NO_3 to NH_4 in the estuary.

During Stage 1, ERP funded several projects to restore intertidal habitat in the Delta. Liberty Island, which consists of 5,209 acres, was breeched approximately ten years and go and was later acquired for conservation. It is undergoing passive restoration to various habitat types including tidal perennial aquatic at the southern end and, freshwater emergent wetland, sloughs, and riparian at the northern end. Nearly 800 acres of fresh and saline tidal emergent wetlands, and 130 acres of valley-foothill riparian, have naturally developed since 1997 (Hickson and Keeler-Wolf 2007). Liberty Island's delta slough habitat is populated with otters, beaver, muskrat and numerous species of ducks and geese. Native fish species include Chinook salmon, splittail, longfin and delta smelt, tule perch, Sacramento pike minnow, and starry flounder. Chinook salmon smolts collected are highly robust with large condition factors. In some areas, native species account for up to 21% of the samples. Despite these improvements in value to wildlife, this tidal marsh is not representative of historic marshes in the Delta and could be improved, especially through an increase in size and the development of a dendritic channel system, a feature that has been all but eliminated from the Delta (DFG 2008b).

Shallow water habitats were previously thought to be good habitat for restoration in the Delta. Domination by extensive tracts of submerged aquatic vegetation (SAV), however, has made this habitat type less suitable for native fish (Nobriga and Feyrer 2007, Nobriga et al. 2005, Brown and Michniuk 2007). Brown and Michniuk (2007) reported a long-term decline in native fish abundance relative to nonnative fish. This decline in native fish abundance occurred coincident with the range expansion of SAV (principally Brazilian waterweed, *Egeria densa*) and nonnative centrarchids. Predation by largemouth bass is one mechanism hypothesized to result in low native fish abundance where SAV cover is high (Brown 2003, Nobriga et al. 2005). Largemouth bass have a higher per capita predatory influence than all other piscivores in SAV dominated intertidal zones (Nobriga and Feyrer 2007). Restoration of intertidal habitat in the Delta must be designed to discourage SAV or native fish may not benefit from the restored areas (Nobriga and Feyrer 2007, Grimaldo et al. 2004). It is expected that SAV can be managed at specific sites through control programs utilizing herbicide applications (or mechanical methods for smaller infestations) (DFG 2008a), and potentially on a larger spatial scale through manipulation of salinity levels and/or water residence times.

New knowledge that should be considered in relation to original ERP goals, objectives, and targets is the relationship between continuing subsidence (particularly in the central and western Delta) and rising sea level (due to projected climate change from global warming). The combination of continuing subsidence and rising sea level makes attainment of ERP targets for tidal marsh habitat in the interior Delta more problematic than originally thought. A more realistic location for tidal marsh restoration, at least in the near-term, is at the periphery of the Delta.

Seasonal Floodplain Habitats

Floodplains have the potential to support highly productive habitats with a direct linkage to aquatic species. Restoration opportunities exist for riparian and riverine aquatic, fresh emergent wetland, seasonal wetland, non-tidal and tidal perennial aquatic, and perennial grassland habitats. Floodplains represent a heterogeneous mosaic of these vegetation types. There has been extensive research on the Yolo Bypass and Cosumnes River indicating that native resident and migratory fish show a positive physiological response when they have access to floodplain habitats (Ribeiro et al. 2004). Floodplains support high levels of primary and secondary productivity by increasing residence time and nutrient inputs into the Delta (Sommer et al. 2004) and provide important spawning and rearing habitat for splittail and rearing habitat for Chinook salmon (Sommer et al. 2001, Sommer et al. 2002, Moyle et al. 2007). Managing the frequency and duration of floodplain inundation during the winter and early spring, followed by complete drainage by the end of the flooding season, could favor native fish over non-natives (Moyle et al. 2007, Grimaldo et al. 2004). Splittail are obligate floodplain spawners (Moyle et al. 2004). Without access to adequate floodplain spawning habitat splittail populations decline drastically as seen during the 1990's. Numerous native fish use floodplains in their life cycles for spawning and growth (Moyle 2002). Floodplain restoration must incorporate as much natural connection with the river as possible to reduce the stranding of native fish.

Duration and timing of inundation are important factors that influence ecological benefits of floodplains. PWA and Opperman (2006) have defined a Floodplain Activation Flow (FAF) for floodplains on the Sacramento River. For floodplains on the Sacramento River an inundation regime that allows for desired ecological outcomes would consist of:

1. Timing: period of March 15 to May 15
2. Duration: active flooding persists for a minimum of seven days (though the floodplain inundation is likely to persist considerably longer)
3. Frequency: an exceedance frequency of 67 percent or two out of every three years. (PWA and Opperman 2006)

FAFs are very important, as are periodic large volume flows. Large scale events are more effective at reworking the floodplain landscape in a natural way. Evidence on the Cosumnes and Sacramento Rivers indicates that dynamic processes are needed to support complex riparian habitats and upland systems which form the floodplain mosaic habitat (Moyle et al. 2007). Native plants and animals have adapted to these stochastic events that are characteristic of California's hydrology. Stochastic events help to control non-native plants and animals. Large scale events reduce stranding by creating channels on the landscape which allow for natural drainage.

Yolo Bypass has shown the greatest promise for large scale (8,500+ acres) restoration of ecological benefits at modest flow rates (2,000 cfs) (PWA and Opperman 2006). This timing and rate of inundation are seen as minimum values for ecological benefits. As the flow rate increases the ecological benefits increase as well. PWA and Opperman (2006) have outlined a methodology for use with other floodplains which can be applied to the San Joaquin River and the lower Mokelumne River. Floodplain expansion will also help alleviate flooding potential. New, alternative levee designs (setback levees) could provide floodplain habitat in the existing channels and oxbows in the Delta. For example, anticipatory erosion control designs that treat levee damage/failure mechanisms and integrate river bank reconstruction with riparian restoration can create functional habitats for fish.

The Cosumnes River is the only remaining unregulated river on the western slope of the Sierra Nevada. The Cosumnes River Preserve comprises 46,000 acres and includes all associated Central Valley habitats and their dependent wildlife. The free-flowing nature of the river allows frequent and regular winter and spring overbank flooding that fosters the growth of native vegetation and the wildlife dependent on those habitats. Research on floodplain benefits along the Cosumnes River show the many ecosystem benefits this type of landscape can have. Ahearn et al.(2006) has shown that floodplain that is wetted and dried in pulses can act as a productivity pump for the lower estuary. With this type of management, the floodplain exports large amounts of Chlorophyll *a* to the river (Ahearn 2006). Native fish have shown many benefits from this type of habitat on the Cosumnes preserve as noted above (Moyle et al 2007, Swenson et al. 2003, Ribeiro et al. 2004, Grosholz and Gallo 2006).

The Department of Water Resources' Flood Protection Corridor Program grants funds for the acquisition of flowage easements; such funding could provide an additional tool to yield floodplain benefits to species seasonally, while accommodating production agriculture in summer, fall, and early winter. The strategy assumes that new floodplains would be shaped and developed based upon availability of flows or changes in river or export operations that might influence/contribute to restoration. In those areas where old flood structures such as Paradise Cut along the San Joaquin River exist, restoration and enhancement opportunities should take into consideration the flow and duration needs of species. A new paradigm is needed for how floodplain and, more importantly, flood control is considered. The historic view has been to construct and design channels that transport water quickly (reducing residence time) rather than providing overflow areas where flows can spread out over terrestrial dominated landscapes (increasing residence time). The energy and forces from the seasonal events are critical processes that shape sediment accretion, suspension, and ultimately floodplain habitats.

Floodplain areas can also provide opportunities for wildlife-friendly agriculture. Delta crops such as rice, grains, corn, and alfalfa provide food for waterfowl and other terrestrial species, and serve as surrogate habitat in the absence of natural conditions. In addition, monitoring of Staten Island, the largest acquisition (conservation easement) funded by ERP during Stage 1 for implementation of wildlife-friendly agricultural practices, yielded a number of recommendations for wildlife-friendly management of lands for terrestrial species:

- Hydrological regime should be the primary consideration for management of harvested fields, to maintain productive habitats for a diversity of waterbirds and other wildlife.
- Although peak abundance of waterfowl varies between years, flooding of early harvested crops such as wheat will provide early migrants and locally produced mallards a food-rich habitat when other habitats (such as seasonal wetlands) are typically dry.
- Flooded acreage should be increased throughout the fall and peak in mid-February to coincide with northern pintails and shorebirds migrating from regions south of the Delta.
- Seasonally flooded wetland water depths should be managed between 2-8 inches from January to mid-March since diving ducks have generally left the region by early January since these shallow areas also provide valuable habitat for shorebirds.

Construction of permanent levees reduces conflicts associated with temporary levee construction concurrent with crop harvest. Permanent levees also provide managers greater flexibility in managing water levels (DFG 2008b).

Aquatic Habitats

Most aquatic habitats in the Delta will be occupied by fish of some type, at some time or another. In planning for future restoration in the Delta and Suisun, it is important to consider which fish will occupy the habitat and when, and what type of benefits fish will gain from the habitat. Fish assemblages in the Delta, each with somewhat distinct environmental requirements, include native pelagic species (e.g. delta smelt and longfin smelt), freshwater planktivores (dominated by non-natives such as threadfin shad and inland silverside), anadromous species (e.g. striped bass and salmon), slough-residents associated with beds of SAV (e.g. centrarchids), and freshwater benthic species (mostly native species including splittail and prickly sculpin) (Moyle and Bennett 2008). A diversity of habitat types is necessary to support the multiple fish assemblages in the Delta; efforts should focus on creating those habitats required by desirable species, while avoiding habitats dominated by undesirable species.

Estuarine aquatic habitats usually vary greatly in space and time. The current configuration and management of water in the Delta maintains stable conditions that are strongly favorable to non-native species, and unfavorable to natives (Moyle and Bennett 2008). Future actions should ensure that aquatic habitats are variable in space and time and include the habitats required by native fish. Ideally, future conditions would also be less favorable to non-native species. There are certain aquatic habitat types that are not desirable. We know that fresh, shallow, low velocity waters support non-native SAV and centrarchids, and this type of habitat should be limited to the extent possible in the future Delta (Brown and Michniuk 2007). Other habitat types would likely be beneficial to native species. Pelagic species would likely benefit from an increase in deep, cool, open water habitats that are exposed to fluctuations in salinity, while native benthic species would likely benefit from the increase in benthic habitat (Moyle and Bennett 2008).

There are some habitat types that are probably inevitable in the future Delta. Due to the increasing threat of levee failure from seismic events, sea level rise, and continuing island subsidence, the Delta is likely to have more large areas of deep, open water (Moyle and Bennett 2008). Characteristics of this new habitat can be managed to benefit native fish. Important attributes that may be at least partially under management control include salinity, contaminant inputs, and connectivity to surrounding aquatic habitats (including channels). The new open water habitats in the Delta will also contribute to an increase in spatial and temporal habitat heterogeneity, and will likely influence (in conjunction with other factors, including climate change) a greater heterogeneity in water quality (Moyle and Bennett 2008). Fish assemblages will respond differently to future environmental changes. As mentioned above, native pelagic species would likely benefit from some of the inevitable change.

There are many unknowns about the future characteristics of flooded island, open water habitat (Moyle and Bennett 2008). These include configuration and location of flooded islands, physical properties such as depth, turbidity, flow, and salinity, biological properties such as productivity of phytoplankton and copepods, and susceptibility to invasion by non-native species such as *Egeria*, centrarchids, and clams. Creation of pelagic habitat is therefore not guaranteed to have a population level benefit to native fish (Moyle and Bennett 2008). Adaptive management, combined with large-scale experimentation on new open water habitat, would help to reduce these uncertainties. This could occur through the planned flooding of at least one Delta island, or through an organized study plan that would respond in the event of an unplanned levee breach (Moyle and Bennett 2008).

New open water habitats may also result from intentional activities. The intentional breaching of levees on islands at the periphery of the Delta in order to create intertidal marsh habitat would result in open water on the portion of the island below the tidal zone (see Liberty Island). Exchange of materials between the restored tidal marsh at the upper end of the island with the adjacent open water would result in higher productivity in the open water habitat. The potential for establishment of SAV and other non-native species in new shallow water environments is a concern. On Liberty Island, SAV has not become a dominant component of the open water habitat. This may be a result of tidal flow velocities, wind-induced disturbance, or some other factor. Upcoming research on Liberty Island (the ERP-funded BREACH III studies) may improve understanding of the dynamics of a large island breach at the periphery of the Delta, and help plan for future marsh/open water restoration projects.

Channel aquatic habitats in the Delta have become artificially simple due to dredging and the armoring of levees to reduce the risk of failure. Fish moving throughout the Delta encounter steep-banked shorelines that are often reinforced with rock. A more complicated structure and bathymetry would provide a diversity of channel habitats to support desirable fishes. Channels lined with native vegetation, either woody riparian or emergent marsh, would provide cover for fish and increase food availability and diversity (Nobriga 2008).

The amount and timing of flow is a feature of aquatic habitats in the Delta. A more natural flow regime would likely favor native species which have evolved life history characteristics that respond to a particular seasonal pattern of flow (Moyle and Bennett 2008). A natural flow regime would eliminate the static nature of Delta aquatic habitats that favor non-native species and would influence many other environmental factors. Flow improves connectivity between habitats by transporting food, fish, and water quality constituents (Nobriga 2008). Adequate flow in the river channels may be especially important for anadromous fish in a future Delta with significantly more open water habitat; flooded islands would be undesirable to juvenile salmon because of a lack of shallow edge habitat and adequate flows would improve emigration success. Freshwater flow and its effect on other important processes are discussed in more detail in the Hydrology section above.

Upland Habitats

Upland habitat in the Delta is best characterized as land well above current sea level (>5 feet in elevation). Habitats in this category include nontidal perennial aquatic, seasonal wetland, perennial grassland, riparian, riverine aquatic, vernal pools, and inland dune scrub. This habitat category highlights the importance of maintaining diverse assemblages of habitats, both spatially and elevationally, as well as allowing the system to respond to drivers of change such as sea level rise.

The focus from a habitat perspective in these upland areas is on preserving and enhancing habitat which supports a diversity of species, ecological processes. Vernal pools provide essential habitat that is critical to the continued existence of endemic populations of amphibians, fairy shrimp, and invertebrate species that have adapted to wetting and drying cycles. Perennial grasslands support vernal pool habitats and processes, by controlling the spread of invasive non-native plants. Although, the non-native annual grass species that now dominate vernal pool grasslands can be controlled through grazing and other management practices (CNPS, 1996).

Improving riparian vegetation and shaded riverine aquatic habitat along waterways could help moderate high water temperatures in the Delta. Large-scale restoration projects are needed to restore the biodiversity and resilience of these habitats used by terrestrial species such as Swainson's hawk and Valley elderberry longhorn beetle. Creating a mosaic of different upland habitat types, increasing their geographic distribution, and enhancing the connectivity between them is important for maintaining genetic diversity of the numerous species which utilize these areas for all or part of their life cycle. Other terrestrial and aquatic species also benefit from the nutrient exchange at the land-water interface once nutrients have been mobilized to aquatic habitats.

With increasing sea level, global warming, and regional climate change, Delta and Suisun Planning Area habitats and species are going to require connectivity to higher elevation areas to respond to these changes. In addition, changes in regional climate are expected to result in precipitation patterns of more rain and less snow, shifting tributary peak runoff from spring to winter, making extreme winter runoff events more frequent and intense. Some upland areas would also be expected to accommodate additional flood flows in new and/or expanded floodplain areas in the long term.

Subsided Lands

The deep Delta (<-5 feet in land elevation) is being identified as an area with potential for subsidence reversal and wildlife-friendly agricultural practices. Given current land use patterns, peat soils, and existing elevations in the deep Delta and current understanding of ecology of flooded islands like Franks Tract, benefits to pelagic organisms and other species would not be achieved by restoration actions on these deeply subsided islands. Considering the evaluations provided in the Delta Risk Management Strategy regarding levee stability, the sustainability of these lands are in question based on interior land elevations and the threat to levee integrity from seismic events, sea level rise, and global warming. As a consequence, the central or deep Delta has minimal opportunity for long-term potential to restore habitats and processes that increase habitat area and food productivity for pelagic organisms. Benefits to endangered native fish species are also questionable since they will likely be deepwater habitats in the long term given their deeply subsided elevations (Lund, et. al, 2007). However, the short-term value of the existing land use practices in this area of the Delta for many other species such as waterfowl and other migratory birds is recognized. Central Valley Habitat Joint Venture (2006) recognizes that agricultural easements to maintain waterfowl food supplies and buffer existing wetlands from urban development may become increasingly important in basins where large increases in human populations are predicted; in addition, ongoing cultivation of rice benefits waterfowl and may help minimize subsidence. The focus from a habitat perspective in deep Delta areas is on actions to counter subsidence and sequester carbon, primarily through the creation of fresh emergent and seasonal wetlands. Efforts should be focused on raising elevations on the interior of the islands as rapidly as possible, while continuing to accommodate agricultural practices that create habitat for wildlife species such as waterfowl and sandhill cranes.

The exposure of bare peat soils to air causes oxidation which results in subsidence, or a loss of soil on Delta islands. Flooding these lands and managing them as wetlands reduces their exposure to oxygen, so there is less decomposition of organic matter. This stops the subsidence and stabilizes land elevations. When greater biomass inputs are present (such as tules and other wetland plants) this biomass accumulation sequesters carbon and helps to stop and reverse subsidence (Fujii 2007). This is desirable, because as subsidence is reversed, land elevations increase and accommodation space (defined by Mount and Twiss [2005] as "the space in the Delta that lies below sea level and is filled with neither sediment nor water") on individual islands is reduced; this reduction in accommodation space decreases the potential extent of negative water quality impacts of salinity intrusion in the case of one or more levee breaks in the Delta.

A pilot study on Twitchell Island funded by the ERP during Stage 1 investigated methods for minimizing or reversing subsidence which has shown great promise for wider implementation on the Delta's subsided lands. By flooding soils on subsided islands to a depth of approximately one foot, decomposition of peat soil is stopped, and conditions are ideal for emergent marsh vegetation to become established. In the pilot project implemented on Twitchell Island, researchers saw some accretion of biomass initially, but noted that accretion rates accelerated and land surface elevation began increasing much more rapidly in 2003-2005. Land surface elevation is currently estimated to be increasing at a rate of ~3.9" per year, and is expected to continue to increase as more biomass is accreted at the project sites over time (Fujii 2007).

Implementation of large scale, whole island approaches to reverse subsidence would be beneficial for multiple purposes. While opportunities for contributions to aquatic species are limited under existing conditions, programs that offer incentives for 10- or 20-year studies for subsidence reversal on large tracts of land could help improve the stability of Delta levees and reduce the level of risk of catastrophic failure. Assuming the higher rates of accretion of 3.9" annually, it is estimated that if subsidence reversal could be pursued throughout the Delta, in 50 years there would be a 50% reduction in accommodation space in the Delta (this reduction in accommodation space jumps to 99% over the next 100 years) (Fujii 2007). Additionally, some of these deeply subsided lands could be used for disposal of clean dredged sediments; this would yield localized flood control improvements as well as help raise land elevations on subsided islands, serving to further reduce accommodation space in the Delta. This reduction in accommodation space would improve long-term sustainability of the Delta and allow future restoration of additional native fish habitat areas.

The USGS is interested in implementing a subsidence reversal program Delta-wide, after further assessing the results of their pilot study on Twitchell Island. Such a program would involve offering financial incentives to farmers to create and manage wetland areas on their lands (Fujii 2007). While the primary objectives of creating wetlands in the Delta would be to reverse subsidence and sequester carbon, there would be significant ancillary benefits to terrestrial wildlife such as waterfowl. Delta agricultural lands and managed wetland areas in the Delta and Suisun Marsh provide a vital component of Pacific Flyway habitat for migratory waterfowl by increasing the availability of natural forage and ensuring improved body condition and breeding success (CALFED 2000b).

Potential Habitat Activities in the Delta and Suisun Planning Area during Phase 1 (more detail available in Appendix E):

Freshwater and brackish tidal marsh

- Hill Slough habitat restoration (Suisun Marsh)
- Mien's Landing restoration (Suisun Marsh)
- Blacklock restoration monitoring (Suisun Marsh)
- Suisun Marsh Property Acquisition and Habitat Restoration – continue property acquisition with willing sellers, restoration, and monitoring activities for lands suitable for tidal restoration; these will be approved through the Proposal Solicitation Process.
- Cache Slough complex
    - Restoration of open water, shallow subtidal, and intertidal habitats, including Prospect and Liberty Islands, and other sites as opportunities arise.
    - Acquisition and planning for restoration of sites along Lindsey Slough associated with the Calhoun Cut Ecological Reserve are critical to meeting ERP's goals of restoring intertidal habitat and for accommodating a rise in sea level. The ERP has tentatively approved $5,989,384 for Solano Land Trust to acquire and plan for restoration in this property.
- Implement and study the planned Dutch Slough restoration project, which would restore up to 483 acres of emergent wetland (a portion of which would be tidal), and generate information on how to best restore tidal marsh habitat. Lessons learned from restoration experiments at this site can be used to restore additional needed marsh areas during Phase 2 throughout the Delta.
- BREACH III/COYOTE project: Continue lower Yolo Bypass technical site evaluation, monitoring, research, and feasibility assessment to greatly improve our understanding of aquatic species' response to tidal wetland restoration. BREACH III will undertake physical

and geomorphic process evaluation, and COYOTE portion will monitor connectivity and key ecological variables (comparing Yolo Bypass and Cosumnes River systems) to assess project performance and the effects of seasonal and interannual hydrologic variability. Results should provide a comprehensive monitoring and research approach that should greatly improve our ability to make sound decisions regarding future management, restoration potential, and flood control needs in the lower Bypass.

- Conduct studies to determine whether fish benefits from tidal marsh that has been demonstrated in the saline portion of the estuary is also true for the freshwater portion of the estuary.
- Study OCAP-mandated actions to determine whether this is sufficient to adequately mitigate for CVP/SWP export impacts, or whether more marsh or other are needed

Flood Management as an Ecosystem Tool, and Bypasses as Habitat

- Continue Aquatic Restoration Planning and Implementation (ARPI) activities – development of habitat enhancement and fish passage improvement in the Yolo Bypass. Continued coordination with Yolo Basin Foundation and other local groups to identify, study, and implement projects on public or private land with willing participants, to create regionally significant improvements in riparian, tidal marsh, and seasonal floodplain habitats and fish passage in the bypass.
- Continue working with the participants in the Yolo Bypass Strategic Plan -- ensure the project scope includes coordination and collaboration necessary to take advantage of previous and current investments in the Lower Bypass in order to ensure the most current available information is being used in the discussions.
- Continue implementing projects at Cosumnes River Preserve – use engineered levee breaches and grading to restore an active and regular flooding regime; restore flooded riparian forest habitat; measure wildlife and plant community response to restoration treatments; monitor changes in surface and ground water hydrology; and monitor geomorphic changes occurring throughout the restored site using remote sensing techniques.
- BREACH III/COYOTE project: Continue lower Yolo Bypass technical site evaluation, monitoring, research, and feasibility assessment to greatly improve our understanding of aquatic species' response to tidal wetland restoration. BREACH III component will undertake physical and geomorphic process evaluation. COYOTE will monitor connectivity and key ecological variables, comparing Yolo Bypass and Cosumnes River systems to assess project performance and the impacts of seasonal and interannual hydrologic variability. Results should be a comprehensive monitoring and research approach that should greatly improve ability to make sound decisions re future management, restoration potential, and flood control needs in the lower Yolo Bypass.

Upland Habitats/Riparian Vegetation

- Acquire land and easement interests from willing sellers in the East and South Delta EMUs that will accommodate seasonal floodplain areas, and shifts in intertidal habitats due to sea level rise, in the future.
- Research to determine scale and balance of flow, sediment, and organic material inputs needed to restore riverine ecosystem function.

- Develop a better understanding of species-habitat interactions, species-species interactions, and species' responses to variable ecosystem conditions in order to better determine natural versus human-induced responses of upland habitat restoration.
- Determine effects of agriculture and urban areas, and anticipate future effects from expansion of these land uses in the future.
- Plan for the effects of climate change.

Ecological Management Unit (EMU) Restoration Opportunities

This section discusses potential changes to Delta processes, habitats, and stressors and presents restoration activities specific to each EMU (Figure 6).

North Delta EMU

CALFED ERP funded the acquisition of both Liberty and Prospect Islands; the northern portion of Liberty Island returned naturally to tidal marsh as a result of a levee breach in the late 1990s, but restoration on Prospect Island remains on hold due to financial and liability issues. Efforts tto acquire fee title interest in the remaining private parcels on Liberty Island and to fund restoration planning and monitoring for the restoration of these properties. The major sloughs to the east between the deep-water ship channel and the Sacramento River, including Miner, Steamboat, Oxford, and Elk sloughs, should be evaluated for improvement as salmon migration corridors. Levees could be reconfigured and set back with terraces and much gentler slopes to promote riparian habitat along these sloughs. Alternative levee designs with terraces along portions of these sloughs would expand the sloughs' carrying capacities during high water and could provide marsh features as well. This approached has been used successfully in the Levees Subventions program on several delta islands. Increases in hydraulic connections at the northern end of the slough complex on the Sacramento River and at the southern end at Prospect Island would increase tidal and net flows through the complex, which along with habitat improvements, could represent important rearing and migrating habitat improvements for salmon and other anadromous and resident fish. Along the Sacramento River channel between Sacramento and Rio Vista, restoration is extremely limited due to levee design. The tradition has been to build up levees in order to maintain trapezoidal channels that convey water quickly and effectively. Alternative levee designs and terraces should be explored here, in conjunction with the levee vegetation framework under development by the Central Valley Flood Control Board and the Department of Water Resources. This would provide greater opportunities for diverse riparian vegetation along major federal levees and to restore and protect existing intertidal habitat and tule berms along the river sides of levees. In addition, habitats would benefit from improving and maintaining flows that contribute to riparian regeneration. These limited habitats may be an important spawning habitat for delta smelt and other native fishes and important rearing and migratory habitats of juvenile salmon and steelhead.

The Cache Slough Complex (CSC) has become an important focus for restoration activities in the north Delta to increase and improve the overall habitat for delta smelt. The CSC includes Liberty Island, Little Holland Tract, Hastings Tract, and Prospect Island. It also includes open water, Calhoun Cut, the pumping plant for the North Bay Aqueduct, the Sacramento Deep Water

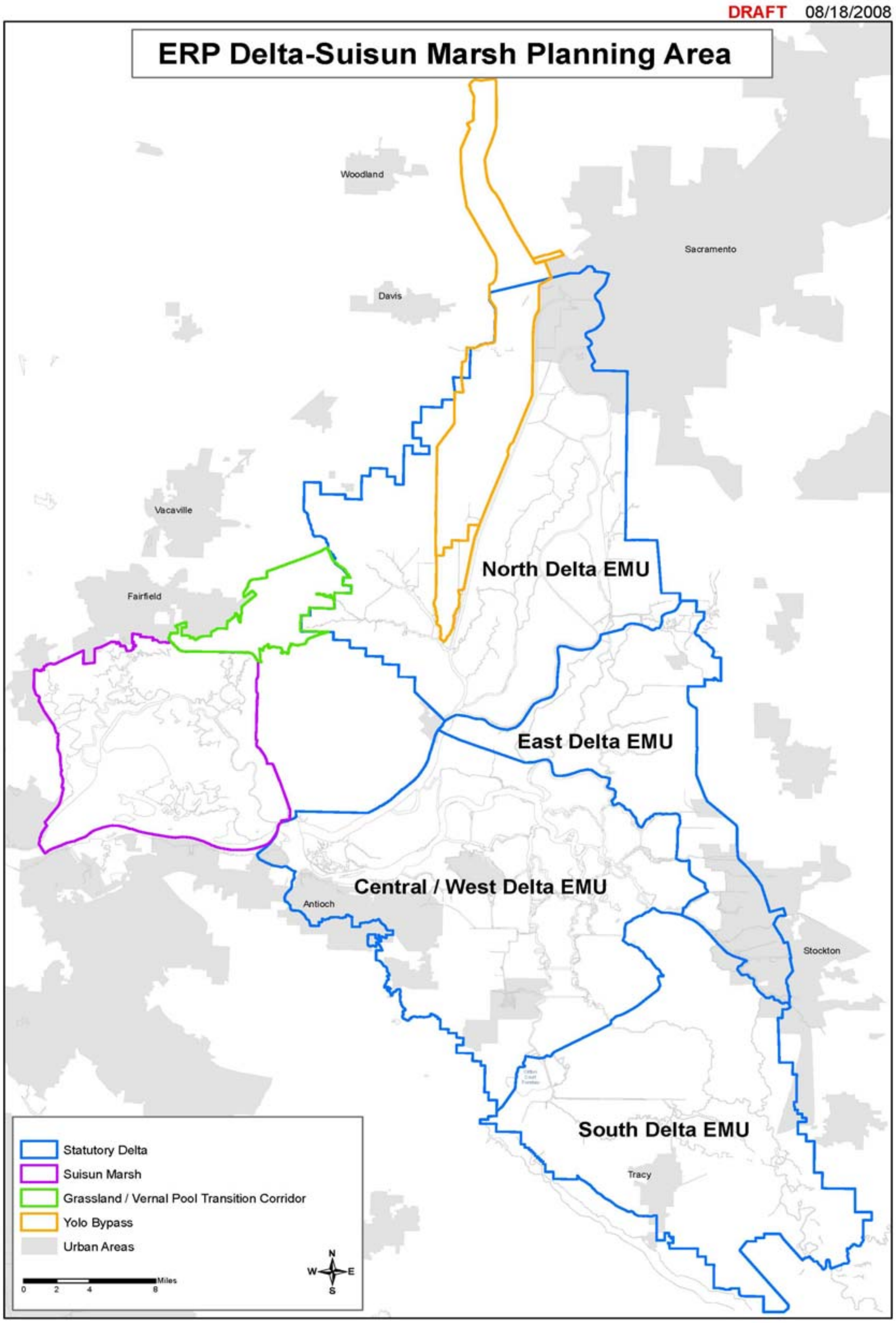
Channel, and Lindsey, Barker, Shag, Cache, Prospect, and Miner Sloughs. Opportunities exist in the CSC for improving our understanding of the processes taking place on the breached, naturally restoring portions of Liberty Island, Little Holland Tract, Prospect Island, and the eastern edge of Egbert Tract which is part of a flood control project. Actions would include land acquisition, focused research on species response and natural processes to guide levee, channel, and bathymetric changes to promote appropriate water circulation, improved water quality, foodweb production, connectivity and important habitat for delta smelt. Specific goals for the CSC include, 1) begin baseline assessments and land acquisition at potential project sites, 2) revisit and revive projects on Prospect Island and Liberty Island that were considered and developed technically, but lost funding or support prior to implementation, 3) initiate a planning effort to develop additional tidal marsh in currently leveed areas at tidal elevations, 4) preserve and enhance high-value habitat on Little Holland Tract and tidally active portions of Liberty Island, and 5) protect native vegetation and habitat in the freshwater sloughs in the area including Lindsey, Barker, and Cache Slough, and 6) support restoration of Calhoun Cut.

In the Yolo Bypass, channel modifications could be constructed to improve connectivity to tributaries in the Yolo basin (e.g. connections with Putah and Cache creeks, and Sacramento River through Sacramento and Fremont Weirs) (CALFED 2000b). Enhancements of the existing infrastructure within the bypass such as improved connectivity in the Toe Drain for migrating fish, rock ramps at the Fremont Weir, and improvements to the existing fish ladder could significantly improve conditions for migrating fish and reduce entrainment after receding floods. Restoration of the lower reaches of Putah Creek in the Yolo Basin Wildlife Area could provide opportunities for improved floodplain habitat and restore a portion of the historical Putah Sink which would help drain the bypass into extensive marsh-slough complexes developed in the shallow islands (i.e., Liberty, Little Holland, and Prospect Islands) at the lower end of the bypass. In addition, Putah Creek and adjacent sloughs would provide seasonal rearing and migrating habitat for juvenile and adult salmon, and other native fishes in the Yolo Bypass.

Over the last couple of years, the ERP Implementing Agency Managers and DWR, in consultation with the Yolo Bypass Interagency Working Group (YBIWG), have set forth recommendations for aquatic restoration activities within the Yolo Bypass with the understanding that monitoring would be critical to inform future planning. Five potential restoration opportunities were identified that will improve conditions for native fish species and enhance populations and recovery efforts, while at the same time maintaining and/or improving existing land conditions for management (Yolo Bypass Interagency Working Group 2006). This five-step sequential restoration plan includes, 1) Putah Creek, 2) Lisbon Weir, 3) additional multi-species habitat development, 4) Tule Canal connectivity, and 5) a multi-species fish passage structure.

The fist step would be to evaluate and develop a plan for the realignment and restoration of lower Putah Creek. This realignment has the potential of creating 130 to 300 acres of shallow water habitat that would help to improve salmonid immigration and emigration to and from Putah Creek, and increase and enhance aquatic and riparian habitat for other native species. Much of this is already underway through the Yolo Basin Wildlife Area Management Plan. Lisbon Weir restoration would include modification and replacement of the weir to provide better fisheries management opportunities in Putah Creek and the toe drain, while improving

Figure 6. Map of Delta EMZ and EMUs



reliability and reducing maintenance. Expansion of existing shallow water habitat is proposed to take place through excavation of a low shelf along the toe drain and creating small-scale set-back levees. Tule Canal connectivity restoration includes areas between Fremont Weir, the Fremont Weir scour ponds, and the toe drain to help reduce stranding of adult and juvenile fish. In addition, other barriers (road crossings, agricultural impoundments) will be identified and evaluated to reduce the impact on habitat connectivity, immigration, and emigration of fish species that use the Yolo Bypass. Lastly, evaluating the feasibility and appropriateness of providing fish passage improvements in and along the Fremont Weir should take place.

ERP has funded several projects in the Cache Slough area, including perennial grassland and vernal pool enhancement activities at the Jepson Prairie Preserve. Vernal pools in the Jepson Prairie Preserve provide habitat for numerous at-risk target species. In addition, ERP has funded the acquisition of conservation easements on up to 1,100 acres along Barker, Lindsey, and Cache Sloughs for increased connectivity.

East Delta EMU

Activities in the East Delta EMU consists of restoration of intertidal and floodplain areas that will improve spawning, rearing, and migration conditions for native Delta fishes. Improvements along the South Fork Mokelumne River and adjoining dead-end sloughs on the eastern edge of the Delta should be the focus of restoration efforts.

Actions along Georgiana Slough, Snodgrass Slough, Cosumnes River, and the North Fork Mokelumne River would improve riparian and tidal marsh habitats and restore ecological processes, such as floodplain-river interactions. The eastern portion of the unit (e.g. South Fork Mokelumne River and adjoining dead-end Beaver, Hog, and Sycamore Sloughs) is ideal for extensive restoration of tidal marsh habitat. Dredge reuse in these areas could also be incorporated to improve local flood control while restoring more favorable shallow water habitat. Tidal headwaters of sloughs and adjacent lands would be opened to provide permanent tidal wetland marsh-slough complexes. Alternative levee designs similar to those identified in the 2000 Levee System Integrity documents and a wider floodplain would improve habitat for fish including resident delta smelt and splittail, and seasonal migrant salmon and steelhead from the Cosumnes and Mokelumne rivers.

Shallowly subsided leveed areas in the western portion of the unit could be used as floodplain overflow basins or subsidence reversal areas in non-tidal permanent wetlands. After many decades of flooding, marsh growth and sediment-laden flood overflow, these areas may become more suitable for conversion to tidal wetlands and riparian corridors.

New concepts could also be considered as part of larger efforts. For example, as the DRMS effort looks at sustainability and risk to Delta infrastructure such as highways, there could be opportunities to pursue innovative partnerships. For instance, along the Highway 12 corridor through the Delta, if planning is underway to improve the stretch between Interstate 5 and Rio Vista, multiple benefits could be found in partnering with Caltrans. A wider, higher stretch of

Highway 12 could incorporate an enhanced levee along Bouldin Island with adjacent managed buffer habitats.

South Delta EMU

Future implementation of the ERP in the South Delta will focus on restoration of ecological processes and habitats. A new feature to be considered for the South Delta EMU is a bypass floodplain and intertidal habitat along the lower San Joaquin River. This floodplain would provide flood protection while allowing for restoration of associated floodplain habitats. Floodplain restoration along the lower San Joaquin River would provide breeding and rearing habitat for native fish in the southern Delta similar to that observed on the Cosumnes River Preserve and Yolo Bypass floodplain areas. Improvements to migration corridors for anadromous fishes may include enhancement of riparian function and shading through modified levee design and possible setbacks along main channels of the San Joaquin River to support riparian vegetation and SRA habitat. Improved floodplain-river connection is also expected to increase foodweb productivity (Moyle et al. 2007).

The northern portion of the South Delta EMU is at an elevation that could support tidal marsh habitat. A large area of tidal marsh could be restored, depending on the elevation and tidal range. Restoration of tidal marsh would include an associated network of sloughs and adjacent habitats such as mud flats and tidal perennial aquatic. Riparian and riverine aquatic habitats could be accommodated in the larger channels. Restoration opportunities in the south Delta EMU will be ultimately influenced by the method of future water conveyance.

Non-urbanized areas immediately east and west of the proposed bypass floodplain lend themselves to restoration of upland habitats such as grassland, riparian, riverine aquatic, and seasonal wetlands. This habitat mosaic would support a diverse assemblage of species, but more importantly would allow the system to respond to drivers of change such as sea level rise and climate change. For example, as tidal areas are displaced in the future due to higher sea level, areas that are currently upland would be expected to accommodate some of this shift in tidal areas and allow for natural succession.

A small portion of the northern section of the South Delta EMU consists of subsided leveed islands, which could accommodate subsidence reversal projects in non-tidal permanent wetlands. Continued seasonal agricultural production would benefit terrestrial species such as the greater sandhill crane and Swainson's hawk. Opportunities for benefits to aquatic species are limited in these areas, although programs for reversing subsidence could potentially make them appropriate for intertidal habitat restoration in the future.

Central and West Delta EMU

The land area of the Central and West Delta EMU consists primarily of deeply subsided leveed islands which could accommodate subsidence reversal experiments in conjunction with non-tidal permanent wetlands. Opportunities for benefits to aquatic species are limited in the Central and West Delta EMU, as invasive species colonize and dominate flooded areas on subsided islands

(DFG 2007). Programs for reversing subsidence could be beneficial in that they could gradually raise land elevations, potentially making them more desirable for intertidal habitat restoration in the future.

There are a few small areas in the Central and West Delta EMU where intertidal habitat could be created, such as the western portion of Hotchkiss and Veale Tracts, the Dutch Slough area, Decker Island, the northern tip of Sherman Island, and a few islands along the Stockton Deep Water Ship Channel. These areas lend themselves to restoration of tidal perennial aquatic habitat, Delta sloughs/mid-channel islands and shoals, emergent wetland, riparian, riverine aquatic, and seasonal wetland habitats.

In conjunction with improved channel configuration to a more dendritic system that connects channels to marshes and increases residence time, freshwater flows could improve productivity and transport of food produced in the Delta to downstream areas in the western Delta and Suisun Bay. Installation of in-Delta barriers to remove connections between rivers (cross-channels) to create a more dendritic system and increase residence time has been suggested to improve productivity (Lund et al. 2007).

Finally, there are non-urbanized areas in the southwestern portion of the Central and West Delta EMU (near Oakley and Byron) which lend themselves to restoration of upland habitats such as grassland, riparian, riverine aquatic, seasonal wetland, and inland dune scrub. These areas are important because they maintain a diverse assemblage of habitats, but more importantly because they allow the system to respond to drivers of change such as sea level rise and other effects of climate change.

Suisun Marsh and Bay EMU

The proposed restoration actions for the Suisun Bay and Marsh are based on the Suisun Marsh Restoration and Management Plan being prepared by the Suisun Marsh Implementation Charter agencies. This planning process builds on a history of protective actions for the Suisun Marsh that initiated in the 1970s. The need for an integrated approach and balance among ecological services desired by landowners and other marsh users led to formation of the Suisun Marsh Charter Group and initiation of the Suisun Marsh Planning effort.

Scoping processes for the draft Suisun Marsh Restoration and Management Plan has identified six preliminary goals for managing the Marsh. These goals are, 1) rehabilitate natural processes wherever feasible in the marshes, wetland and aquatic habitats, with minimal human intervention for native species and the communities upon which they depend, 2) protect, restore, and enhance habitats where feasible for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics, 3) provide long-term protection of the area's resources by maintaining the integrity of the levee system, 4) manage the area to prevent establishment of new non-native species, and reduce established non-native species populations, 5) improve and/or maintain good water and sediment quality for beneficial uses, to support a healthy and diverse aquatic ecosystem, and to eliminate to the extent possible toxic impacts to people, fish and wildlife, and 6) maintain heritage waterfowl hunting on the area and increase public awareness of the area's natural resources.

Tidal restoration objectives for the marsh include: 1) restoration of tidal marshes contiguous with upland transitions, 2) expansion of distribution and amount of shallow subtidal habitat and sloughs, 3) restoration of natural processes and increased productivity and nutrient export to adjacent waters, and 4) enhance habitat for sensitive and listed species.

In evaluating appropriate areas for tidal marsh restoration, constraints have been identified to include subsidence, a limited sediment supply, protection of infrastructure, salinity levels, protection of neighboring properties, and a reduction in managed marsh. An additional important consideration is sea level rise and the ability of tidal marsh to migrate naturally to undeveloped uplands. Restoring tidal marsh contiguous with upland grasslands will also provide a refugia for animals during extreme high tide events. Areas currently being planned for restoration or in the process of being restored to tidal habitat are the Blacklock, Hill Slough, Montezuma wetlands, and Mein's Landing.,

Shallow-water, wetland, and riparian habitats within the Marsh and along the shorelines of the Bay will be protected and improved, where possible. Upland habitats adjacent to riparian and wetland habitats will also be protected and improved. Efforts will focus on restoring tidal slough channels and increasing acreage open to tidal flows (e.g. by removing or opening levees) and providing connectivity among habitat areas to aid in the recovery of species, such as the salt marsh harvest mouse, clapper rail, and black rail. Providing natural habitat transitions between wetland habitats and adjacent upland habitats would provide habitat required by many special status plant species, protect wetland habitats from disturbance, and provide area for the natural relocation of tidal wetlands with future sea level rise.

Diverting water from Suisun Marsh channels for managed nontidal wetlands and controlling salinity of water entering the marsh through Montezuma Slough will continue, but with consideration for maintaining the natural hydrologic regime and salinity levels of the slough and marsh. Water quality standards specified in the 1995 Water Quality Control Plan will be re-evaluated as restoration targets for the eastern marsh and at several locations in the central marsh.

Improving marsh and slough habitats will benefit Chinook salmon, delta smelt, splittail, and other estuarine fish that spawn or rear in the marsh and Suisun Bay. A healthy Suisun Marsh-Bay ecosystem will be an important link in the estuarine foodweb by improving primary and secondary productivity. Marsh and Bay productivity will improve as freshwater inflow events increase in dry and normal years and acreage of tidal wetlands and associated tidal perennial aquatic habitat increases.

Effort will be made expand restoration in the northeastern portion of Suisun Marsh and restore connectivity with transition zones between areas such as the Jepson Prairie Preserve in the Yolo Basin Ecological Management Zone.

<u>EMU Near-term acquisition and enhancement priorities</u>

North Delta EMU:

Cache Slough complex – mosaic of open water, shallow subtidal, intertidal, and terrestrial habitats. The Cache Slough complex includes Prospect Island (intertidal), Liberty Island (open water and intertidal), as well as Little Egbert Tract (floodplain, potential open water habitat experiment).

Yolo Bypass – mosaic of floodplain and terrestrial habitats. The Yolo Bypass area has been under investigation for several years for its potential to provide floodplain habitats benefiting Delta species, and it is a high priority of the ERP to provide these functions in this area in the near term. In addition, private entities (Westlands Water District, Metropolitan Water District) are currently acquiring properties in the Yolo Bypass with the intent of restoring habitats and securing their water supply. Over the longer term, this area is expected to provide intertidal habitat areas as well, as it accommodates sea level rise.

Suisun Marsh and Bay EMU:
The Suisun Marsh and Bay would include restoration of a mosaic of open water, shallow subtidal, intertidal, and terrestrial habitats, in accordance with implementation of the Suisun Marsh Implementation Plan (currently under development).

Suisun-Cache Slough Grassland/Vernal Pool Transition Corridor:
This corridor of grasslands, vernal pools, and seasonal wetlands is intended to be a connector between the high-priority habitat areas of the Cache Slough complex and Suisun Marsh and Bay. While at this time the corridor is envisioned to largely consist of seasonal wetlands and vernal pools, it is possible that channels may be constructed within this corridor, to provide a migratory route for endemic species that use the Delta and Suisun Bay, such as delta and longfin smelt, and anadromous fish species.

Central/West Delta EMU:
The Dutch Slough habitat restoration project proposes to create intertidal and shallow subtidal habitats on lands adjacent to the open water areas of Big Break, north of Oakley. Due to the expenditure of funds to acquire the properties and the ecological benefits the restoration is expected to yield, this is a high-priority project for implementation in the near term.

East Delta EMU:
Cosumnes-Mokelumne area – mosaic of floodplain, intertidal, and terrestrial habitats. The confluence of the Cosumnes and Mokelumne river systems has been an area of extensive property acquisitions (Cosumnes River Preserve) for the ERP, and continues to be an important area for restoring floodplains and seasonal wetlands (it also accommodates compatible land uses such as wildlife-friendly agriculture). In the near term, ERP plans to continue to restore acquired properties to floodplain and intertidal habitats (McCormack Williamson Tract).

Of medium priority in the near term will be land acquisitions to accommodate shallow subtidal and intertidal habitats in the future as sea level rises. However, restoration of these properties (many of which are currently in private ownership), even if they are acquired in the near term, will not be a priority until isolated conveyance is in place.

South Delta EMU:

Of medium priority in the near term will be land acquisitions to accommodate floodplain areas, as well as shallow subtidal and intertidal habitats in the future as sea level rises. However, restoration of properties (many of which are currently in private ownership), even if they are acquired in the near term, will not be a priority until isolated conveyance is in place.

Stressors

Restoration of critical ecological processes to improve the quality and extent of desirable habitats is only part of the solution to species recovery in the Delta and Suisun Planning Areas. The ERP has identified several stressors that negatively affect native species, ecological processes, and habitats within the planning area. Of particular note are stressors relating to water diversions, barriers to connectivity of habitats (such as levees), non-native and invasive species, and water quality.

Water Diversions

Water diversions have been shown to entrain large numbers of fish. There are more than 3,300 diversions that take water from the Sacramento and San Joaquin Rivers, their tributaries, and the Delta (Herren and Kawasaki 2001). Almost all (98.5%) of these diversions are “either unscreened or screened insufficiently to prevent fish entrainment” (Herren and Kawasaki 2001). In order to keep fish, especially juvenile salmonids, from being entrained in these diversions, the State of California has enacted fish screen requirements in the Fish and Game Code (Odenweller 1994).

Within the planning area, the largest water diversions are the export facilities of the State Water Project (SWP) and Central Valley Project (CVP) in the south Delta. In addition, there are two power plants in Antioch and Pittsburg which divert large amounts of water for their operations, and several diversions that supply water to Contra Costa Water District and cities on the periphery of the Delta. Finally, there are over 2,000 individual small diversions (<100 cfs) serving agricultural parcels. A limited number of detailed studies on these small diversions (Nobriga et al. 2004, Cook and Buffaloe 1998, and Spaar 1994) concluded that their effects on delta smelt are likely very small or in some cases could not be determined. Fish screens on these small diversions were not widely pursued in the Delta and Suisun Planning Areas during ERP Stage 1, largely due to high costs and potentially small fish population benefits compared to other screening projects.

Export operations of the SWP and CVP in the south Delta have both direct and indirect impacts on Delta fishes. The amount and timing of water exports from the Delta affect the level of entrainment. Export operations substantially affect water movement through Delta channels and sometimes result in net reverse flows in Old and Middle Rivers, the San Joaquin River at its confluence with the Sacramento River in the western Delta, and other channels and sloughs near

the export facilities. Export operations alter tidal flows to the point that in some channels the ebb tide is eliminated at times (Gartrell, pers. comm.). These hydrodynamic conditions affect water quantity and quality due to higher water velocities and reduced residence time. This alters various habitat types that are dependent upon natural flow patterns. In addition, the rate at which

water is diverted from the Delta affects the residence time of water in Delta channels which, in turn, affects primary and secondary production (DFG 2008b).
Loss of fish at water diversions could be reduced by effectively screening, reducing, and/or relocating diversions. The ERP devoted a large amount of resources to screen several diversions during Stage 1. These resources were focused mainly on fish screens and fish passage projects at large diversions and dams along the Sacramento and San Joaquin Rivers and their tributaries. Ultimately, methods for reducing entrainment at the SWP and CVP pumps in the south Delta will depend on the method of conveyance chosen in the BDCP planning process.

The current state of knowledge on the cost-effectiveness and feasibility of fish screens has been the subject of several ERP and Science Program workshops in 2007. A Core Workgroup has been designed with members from DWR, CDFG, USFWS, NOAA, BOR, Regional and State Water Boards, Army Corps, USEPA, and academia. DFG has volunteered to be the "lead agency" performing the various logistic and coordination functions for the group. These discussions are expected to inform new strategic approaches to lessening the impacts of water diversions on fish and aquatic organisms, and to offer guidance on future prioritization of fish screening actions, and monitoring.

Non-native Aquatic Invasive Species (AIS)

California Aquatic Invasive Species Management Plan Goal & Objectives
The California Aquatic Invasive Species Management Plan (CAISMP) provides a common platform of background information from which state agencies and other entities can work together to address the problem of aquatic invasive species. Beyond providing information, the goal of this planning process has been to identify the major objectives and associated actions that need to be attained in order to minimize the harmful ecological, economic and human health impacts of aquatic invasive species in California.

Eight major objectives have been identified:

1. Improve coordination and collaboration among the people, agencies, and activities involved with AIS.
2. Minimize and prevent the introduction and spread of AIS into and throughout the waters of California.
3. Develop and maintain programs that ensure the early detection of new AIS and the monitoring of existing AIS.
4. Establish and manage systems for rapid response and eradication.
5. Control the spread of AIS and minimize their impacts on native habitats and species.
6. Increase education and outreach efforts to ensure awareness of AIS threats and management priorities throughout California.
7. Increase research on the baseline biology of AIS, the ecological and economic impacts of invasions and control options to improve management.
8. Ensure state laws and regulations promote the prevention and management of AIS introductions. [DFG 2006]

The plan goal, objectives, strategies, and specific actions were developed with input from a series of stakeholder scoping meetings, interagency staff communications and public workshops held in 2002 and 2006. These meetings, as well as many individual conversations and extensive review, played a role in making the plan as comprehensive and responsive to AIS issues in California as possible. Each objective is supported by a series of strategic actions with the implementing entities and cooperating organizations identified, and costs included where appropriate. Dedication of permanent funding to support permanent AIS staff and agency programs will be critical to effectively addressing AIS in California.

AIS have had a dramatic effect on the Bay-Delta ecosystem by altering the foodweb and physical habitats, and by competing with or directly predating upon native species. Depending on the species and the level of invasion, there are different management responses that would be pursued; the CAISMP includes examples of management responses to specific invasive species in the planning area. Efforts to avoid additional introductions to the Bay-Delta and to control established invasive species will be given high priority. As mentioned in the discussion of salinity fluctuation above, periodic intrusion of salinity into the Delta may help to reduce certain invasive species, and give native species a competitive advantage. AIS of particular note in the planning area include:

- ***Centrarchids***

The most common centrarchids in the Delta are the largemouth bass, smallmouth bass, spotted bass, bluegill, warmouth, redear sunfish, green sunfish, white crappie, and black crappie. The increase in non-native submerged aquatic vegetation (SAV) and the reduction of spring water velocities and summer salinity due to diversions when these fish are spawning have probably increased populations of these fish (Brown and Michniuk 2007). Centrarchids, in conjunction with SAV, can have a large negative impact on native fish via predation and competition (Nobriga and Feyrer 2007, Brown and Michniuk 2007).

The presence and distribution of centrarchids may be manipulated by managing environmental conditions such as water velocity, salinity, turbidity, and the extent of SAV coverage. Management actions to control these conditions, and the potential impacts of these actions on the numbers and distributions of centrarchids, will be evaluated using the DRERIP conceptual models for potential site-specific) restoration and other management actions.

Aquatic invertebrates

- ***Overbite Clam***

The "overbite" clam (*Corbula amurensis)*, was first observed in 1986 and has since become extremely abundant in the Bay and western Delta (Carlton et al. 1990). This species is well adapted to the saltwater areas of the Bay-Delta and is largely responsible for the reduction of phytoplankton and zooplankton in the Bay-Delta region (Kimmerer 2006). This loss of primary and secondary production has drastically altered the food web and is one of the possible causes of the POD (IEP 2007b). *Corbula* have been shown to bioaccumulate selenium (Linville et al. 2002). This could have reproductive implications for fish that feed on *Corbula*.

- ***Asian Clam***

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

Because *Corbula* and *Corbicula* have become so well-established in the estuary, there is currently no known environmentally acceptable way to treat or remove these invertebrates (DFG 2006). The only apparent management action at this time is to determine whether the manipulation of environmental variables (such as salinity) can be used to manage their distribution in the estuary during certain months of the year.

- ***Zebra Mussel***

While not yet present in the Delta, the zebra mussel (*Dreissena polymorpha)* is highly invasive and has the potential to become established in the planning area. This species would pose similar threats to the ecosystem as noted for *Corbula* and *Corbicula*. Zebra mussels are the only freshwater mussel which can secrete durable elastic strands, called byssal fibers, by which they can securely attach to nearly any surface forming barnacle-like encrustations. Zebra mussels typically colonize at densities greater than 30,000 individuals per square meter. One of the most predictable outcomes of a zebra mussel invasion and a significant abiotic effect is enhanced water clarity. This is linked to a greatly diminished phytoplankton biomass. For example, rotifer abundance in western Lake Erie declined by 74% between 1988 and 1993, a time coincident with the establishment of an enormous zebra mussel population beginning in 1989. [Claudi and Leach 2000]

- ***Quagga Mussel***

Threats from the quagga mussel (*Dreissena bugensis)* are thought to be similar to those of the zebra mussel (Claudi and Leach 2000). Quagga and zebra mussels have very similar life history strategies with the exception that quagga can live at greater depths (Claudi and Leach 2000). An interagency state and federal Coordination Team was established to coordinate management response to the threat of further quagga spread in California. Three subcommittees were established: Outreach and Education, Monitoring, and Sampling/Laboratory Protocols. The quagga mussel scientific advisory panel (SAP), convened in April 2007, was charged with considering the full range of eradication and control options without respect to cost. Under the direction of DFG, the San Francisco Estuary Institute is performing a phased risk assessment of California waters in order to rank sites for further monitoring based on the likelihood that quagga or zebra mussels will become established.

A relatively recent development with respect to both zebra and quagga mussels is that a common soil bacterium, *Pseudomonas fluorescens*, has proven to be very effective in controlling populations, with a 95% kill rate at treatment sites. The bacterium produces a toxin which destroys the invasive mussels' digestive gland, killing them. Research has indicated that the bacterium does not harm untargeted native fish and mussel species (Science Daily 2007). It is probable that this bacterium would be used to control zebra and quagga mussel populations.

- ***Chinese Mitten crab***

Another relatively new arrival to the Bay-Delta from Asia is the Chinese mitten crab (*Eriocheir sinensis*). This crab spends most of its life in fresh water and migrates downstream to spawn in salt water. Mitten crabs were first captured in south-Bay shrimp trawls in 1993. Although these crabs may have an adverse effect on the red swamp crayfish (another non-native species), its greatest potential impact on the Bay-Delta may be its effect on levees. Mitten crabs dig burrows in clay-rich soils where banks are steep and lined with vegetation. These burrows accelerate bank erosion, slumping and, over time, may pose a serious threat to Delta levee integrity.

- ***Zooplankton***

Introduced zooplankton species have become important elements of the Bay-Delta. *Eurytemora affinis* was probably introduced with striped bass around 1880. Until recently, it was a dominant calanoid copepod of the entrapment zone. In the last decade, however, *Eurytemora* has been replaced by two calanoid copepods introduced from China. It has been postulated that this replacement was a result, in part, of *Eurytemora*'s greater vulnerability to overbite clam grazing (Bouley and Kimmerer 2006).

The native mysid shrimp *(Neomysis mercedis)* began dwindling in abundance in the late 1970s. Its population decline was also affected by competition with *Acanthomysis aspera*, an introduced mysid shrimp of somewhat smaller size but similar feeding habits. The decline of the native shrimp species has been identified as another possible cause for trophic problems in the Delta.

- ***Plants***

Non-native aquatic weeds in the planning area pose serious problems to native flora and fauna. Research, monitoring, mapping, and control are needed for *Egeria*, water pennywort, Eurasian watermilfoil, parrot feather (which are cumulatively referred to as SAV) and water hyacinth. These weeds flourish in a wide geographic area, sometimes in high densities, and are extremely harmful because of their ability to displace native plant species, harbor non-native predatory species, reduce foodweb productivity, reduce turbidity, or interfere with water conveyance and flood control systems. Areas with large densities of SAV hav been implicated in the reduction in native ichthyoplankton and adult fish (Grimaldo et al. 2004, Brown and Michniuk 2007). Restoration of tidal habitats must be designed to reduce SAV if conservation goals are to be met (Nobriga and Feyrer 2007). Although SAV has become widely established throughout the Delta, it is likely manageable on a relatively localized scale, through the use of aquatic herbicides or mechanical control methods.

Water Quality

Contaminants are organic and inorganic chemicals and biological pathogens that can cause adverse physiological response in humans, plants, fish, or wildlife. Contaminants are found in many forms and have the ability to affect the ecosystem in many ways and at different life stages of individual species. Contaminants may cause acute toxicity, such as mortality, or chronic toxicity, such as reduced growth, reproductive impairment, or other subtle effects. Contaminants can also affect the sustainability of healthy aquatic food webs and interdependent fish and wildlife populations (CALFED 2000a). Some contaminants are naturally occurring at low levels, but with human disturbance, contaminants can be exposed to the environment in amounts or concentrations high enough to pose life-altering effects.

- ***Pesticides and Other Chemicals***

Water quality toxicity has been documented in shellfish, fish, mammals, and birds from the Bay-Delta and its mainstem rivers and tributaries, and is most frequently caused by runoff from agriculture, urban areas, and abandoned mines (CALFED 2000a). Genotoxic effects are considered among the most serious of the possible side effects of agricultural chemicals. If a chemical reacts with nuclear DNA, it may be mutagenic and carcinogenic to the exposed organisms. A chemical can also alter gene expression without altering an organism's DNA. The prolonged exposure to such chemicals may lead to effects including heritable genetic diseases, carcinogenesis, reproductive dysfunction, and birth defects (Patel et al. 2007).

Herbicides and pesticides are also of concern because of their potential toxicity to species in the planning area. Pesticide use has changed since Stage 1 began in 2000. Previously, organophosphate (OP) pesticides such as diazinon and chlorpyrifos were widely used. However, as OP toxicity received increasing attention from regulatory agencies, the use of OP pesticides decreased in favor of increased use of pyrethroid pesticides. Pyrethroid pesticides are less acutely toxic to vertebrates, but are more difficult to detect in water due to their tendency to adsorb strongly to sediment particles. Pyrethroid pesticides result in sublethal effects to aquatic vertebrates and lethal effects to invertebrates, and are believed to be one of the causes of the POD. Preliminary data suggest that both organophosphate and pyrethroid pesticides may have contributed to the higher incidence of toxic events in 2007, a dry year) (IEP 2008). Recent results from studies indicate that pyrethroids are causing significant toxicity to benthic organisms in 25-60% of the waterbodies tested, particularly creeks and drainages. Other studies have shown that very low concentrations of OP pesticides may interfere with sensory cues needed for salmonid migration (DFG 2008b). Laboratory studies of salmon with sublethal exposures to pyrethroids show significant increased susceptibility to mortality from disease (DFG 2008b). Contaminants toxic to fish and wildlife could be reduced by changing land management practices and chemical uses on urban and agricultural lands that drain into the Delta. The effects of these contaminants need to be viewed from an ecosystem perspective, but in order to characterize ecosystem effects, individual components such as fate and transport, distribution and concentrations throughout the watershed, toxicity to individual species, and other parameters need to be defined and understood (DFG 2008b). Sublethal impacts on populations of fish and foodweb organisms have been difficult to document, however, monitoring has shown that many waterways in the Central Valley contain high levels of agricultural and urban discharges. Predominant pesticides detected throughout Central Valley waterways were diazinon, chlorpyrifos, the herbicides simazine and diuron, and DDT breakdown products (CVRWQCB 2007).

The length of time during which toxicity is present is an important aspect of water quality contamination because of the potential for resident organisms' increased exposure and subsequent chronic effects. Delta sloughs are particularly susceptible because of their longer water residence time. Researchers conducting quarterly monitoring of Delta back sloughs that receive both urban and agricultural runoff yielded results indicating that several of the sloughs, notably French Camp and Paradise Cut, had toxicity that persisted for up to 15 days (DFG 2008b). In light of the ERP objective to enhance heterogeneity of habitats throughout the planning area in part by increasing the residence time of water in channels and sloughs, toxicity will need to be evaluated in terms of individual contaminants and the species that may be affected. The ERP implementing agencies will continue to work cooperatively with the State and Regional Water Quality Control Boards to update Basin Plans and implement actions to improve water quality. The Regional Boards have assembled extensive data on water quality in the Delta and Suisun Bay through its Total Maximum Daily Load (TMDL) process as well as its Irrigated Lands Conditional Waiver program (initiated in 2004) (DFG 2008b). The first seven years of ERP implementation included funding for various water quality studies, the results of which demonstrated a trend toward reduced pesticide use, as determined through surveys of California growers, and development of Best Management Practices (BMPs) for pesticide use and for control of agricultural runoff. If pesticide use trends continue downward, and BMPs become more widely used, then impairments in water quality from pesticides are likely to decrease in both distribution and severity (DFG 2008b).

Ammonia is another contaminant of concern for aquatic species. Ammonia appears in the aquatic environment as both a dissolved gas which is toxic to fish, and as unionized ammonia, NH_4, also known as ammonium (Swanson 2008). As discussed in the "Aquatic Foodweb Dynamics" section, ammonium (NH_4) is a contaminant that is receiving more attention for its potential role in the decline of the aquatic food web. The availability of nitrate (NO_3) in the estuary is a key component of primary productivity, as phytoplankton requires uptake of NO_3 (dissolved inorganic nitrogen [DIN], consisting of NO_3 and NH_4 and others) to produce food for zooplankton and other lower trophic level species that fuel the aquatic estuarine food web. If phytoplankton do not uptake nitrate, primary production by phytoplankton cannot occur, and the food web is impacted accordingly. Field measurements and enclosure experiments are showing that when concentrations of ammonium (NH_4) greater than 4 micromoles per meter are present in the estuary, the uptake of NO_3 by phytoplankton is inhibited. This is the cause of low NO_3 utilization most of the year (Dugdale et al. 2007). As one consequence, the nitrogen component of the ammonium produces toxic blue-green algae (*Microcystis*) blooms rather than diatoms, since diatoms grow faster in the presence of nitrate than ammonium (Swanson and Kimmerer 2008). Advanced secondary treatment at wastewater treatment plants could convert NH_4 to NO_3, making all forms of DIN available for primary production, with substantial increases in potential phytoplankton biomass and primary production in spring and perhaps in summer as well, in Central SFB, San Pablo Bay, and Suisun Bay (Dugdale et al. 2007).

Finally, some contaminants are of increasing concern because they act as endocrine disrupters in humans and/or animals. Diethylstibestrol (the drug DES) and certain pesticides (dioxin, PCBs, and DDT) are known endocrine disrupters in humans. In addition, plasticizers such as polybrominated diphenyl ethers (PBDEs) used as a fire retardant in furniture, televisions and computers may bioaccumulate in fish and yield sublethal toxic effects. Studies conducted as part of IEP's POD investigations showed some evidence of low frequency endocrine disruption in adult Delta smelt males. In 2005, 6% of individuals were intersex, with immature oocytes in their testes (IEP 2008).

- ***Dissolved Oxygen***

Dissolved oxygen (DO) is the form of oxygen upon which most aquatic life depends. DO is provided by photosynthesis, atmospheric diffusion, and aeration from wind/wave action. DO is consumed by microbial processes such as respiration and nitrification, both of which are stimulated by nutrients such as nitrogen and carbon. Oxygen depletion results from oxygen consumption exceeding oxygen production, and can result in mortality to fish and other aquatic organisms. Oxygen depletion is exacerbated by warm water temperatures, as warm water can hold less DO than cold water. Therefore, DO concentrations typically are lowest during the summer months when river temperatures are warmer. Also, as salt concentrations increase DO decreases.

Low DO can lead to hypoxia in aquatic species. Hypoxia occurs in aquatic environments when the DO concentration is reduced to a point that is found to be detrimental to aquatic organisms. Sublethal levels of hypoxia may result in deleterious effects to fish species, including malformation in fish embryonic development, delays in embryonic development, and altered balance of sex hormones during embryonic stages. Subsequent sexual development may also be affected. Studies show that hypoxia can cause endocrine disruption in adult fish. (Wu et al. 2003, Thomas et al. 2007) Impairments at the earlier stages of the life cycle may subsequently reduce the fitness and therefore chance of survival of individuals in natural populations (Shang and Wu 2004).

Low levels of DO impair fish production, migration, and juvenile rearing, and is a potential cause of mortality in other aquatic organisms (CALFED 2000a,b). There is evidence that low DO levels create a migration barrier for San Joaquin River fall-run Chinook salmon. Low DO levels may also negatively affect the San Joaquin River's benthic and water column biotic communities and ecological processes (CALFED 2000a).

Low DO levels are most problematic to aquatic organisms in the south Delta, particularly the lower San Joaquin River and the Port of Stockton's Deep Water Ship Channel (DWSC). The CVRWQCB adopted a phased TMDL for DO on the lower San Joaquin River in 2005. Pending more study, a final TMDL is expected to be adopted sometime in 2009. Studies funded by the ERP during Stage 1 have identified three main contributing factors to the low DO levels in the DWSC, 1.loads of oxygen-demanding substances from upstream sources that react by numerous chemical, biological, and physical mechanisms to remove DO from the water column, 2. DWSC geometry impacts that add or remove DO from the water column, resulting in increased net oxygen demand, and 3. reduced flow through the DWSC that adds or removes DO from the water column, resulting in increased net oxygen demand (DFG 2008b, San Joaquin River DO Technical Working Group 2007.)

In addition, low DO appears to be a problem for aquatic species in the Suisun Marsh. Evidence of fish kills and early results of some studies indicate that low DO in water and drainage from managed wetlands are significant threats to aquatic species in the Suisun Marsh and Bay (DFG 2008b). The Regional Boards have assembled extensive data on the DO problem through its Total Maximum Daily Load (TMDL) process. As noted above, ERP implementing agencies will continue to work cooperatively with the State and Regional Water Quality Control Boards in updating Basin Plans and taking actions to meet mutual goals for improving DO conditions in the south Delta.

- ***Mercury and Methylmercury***

Mercury is a toxic metal that has no known beneficial biological function in fish, birds, or mammals. Historical mercury mining in the Coast Range and mercury use associated with gold mining in the Sierra Nevada have left an environmental legacy of pervasive mercury contamination in many northern California watersheds. The dominant forms of mercury in mining wastes are inorganic (cinnabar and quicksilver), but under certain environmental conditions, a small proportion of the inorganic mercury is converted by microbial activity to methylmercury, a more toxic, organic form of mercury that readily bioaccumulates in aquatic and terrestrial food webs. Because methylmercury increases in concentration with each step up the food chain, the species at greatest risk to exposure are top predators including fish species such as bass and sturgeon, and fish-eating birds. [Alpers 2007]

Some habitats more readily facilitate the methylation of mercury, resulting in greater exposure to wildlife. These habitats include high tidal marsh, seasonal wetlands, and floodplains. Perennial aquatic habitats and low tidal areas have relatively lower methylation potential. A working hypothesis that explains these variations recognizes that higher methylmercury habitats have extended dry periods in which soil and sediment completely dry out, which raises the possibility that oxidation of mercury during the dry periods leads to higher concentrations of reactive mercury during subsequent flooding, when sulfate- and/or iron-reducing bacteria facilitate methylation. The oxidation of carbon and sulfur compounds during dry periods may also play an important role in increasing mercury methylation rates during subsequent flooding. [Alpers 2007] Ongoing studies at the Yolo Basin Wildlife Area include development of BMPs to manage new habitats in ways that avoid or minimize the potential methylation of mercury at restoration sites.

Prior to certification of the CALFED ROD in 2000, a favored working hypothesis among mercury scientists was that the Delta would be a zone of net methylation of mercury. Monitoring data for water and fish indicate that the central Delta is actually lower in methylmercury concentration than tributary areas such as the Yolo Bypass, Cosumnes River, and San Joaquin River. Preliminary mass balance calculations indicated a net loss of methylmercury in water as it flows through the Delta (CVRWQCB 2006). The main causes of the methylmercury loss are currently thought to be photodemethylation and sedimentation. Another possible contributing factor to the lower levels of methylmercury in the central Delta is that high concentrations of reduced sulfur may serve to make reactive forms of mercury less available to the methylation process. Mercury demethylation processes may be very important in the Delta, though further experiments and field investigations are needed to quantify these processes (Alpers 2007). In general, potential methylation of mercury from actions to increase turbidity or primary production must be weighed against the negative impacts associated with not restoring these critical aquatic habitat types to help recover species.

Improvement of the sediment trapping efficiency of the Cache Creek Settling Basin has been identified by the Regional Board as one of the most cost-effective ways to reduce loads of mercury and methylmercury in the Yolo Bypass, one of the largest contributors of these contaminants to the Delta and areas downstream to San Francisco Bay (CVRWQCB 2006).

The current regulatory environment for mercury includes Total Maximum Daily Load (TMDL) development for mercury and methylmercury. A TMDL-based Basin Plan Amendment was recently approved by the SWRCB for San Francisco Bay and a TMDL-based amendment has been proposed by Central Valley RWQCB staff for the Delta. There is a general concern that increased concentrations of methylmercury in water, sediment and biota might result from any of several types of actions that are being taken or contemplated by the ERP, including restoration of wetland and floodplain habitats in the Bay-Delta and changes in the conveyance of fresh water across the Delta. If current regulatory trends continue, TMDLs for mercury and methylmercury in San Francisco Bay, the Delta, and their tributaries will be key drivers of mercury research, monitoring, and remediation over the next several years. [Alpers 2007]

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

- ***Selenium***

Selenium is present with salts in the western San Joaquin Valley, and in general, when it reaches a concentration of 5-10 micrograms per gram, it becomes toxic to some aquatic species (e.g. *Corbula*) and the species that consume them. Ecological effects of selenium are largely governed by dry season and low flow conditions; this is when selenium concentrations are highest. Documented effects of selenium toxicity include deformities in white sturgeon larvae and inability of eggs to hatch. Reproductive effects of selenium on white sturgeon is highest in Suisun Bay in fall and early winter, coinciding with the “first flush” rain event. It is believed that mature splittail may also be adversely affected by selenium (Luoma 2008).

Certain changes in Delta infrastructure and conveyance could result in changes to transport routes, source mixtures, and flushing times of water and contaminants within the Delta (Monsen et al. 2007). Conveying fresh Sacramento River water around the Delta, would likely require management strategies to reduce the potential for selenium bioaccumulation in the Planning Area and downstream in San Francisco Bay, because Delta channels would consist of a higher proportion of San Joaquin River water which provides the bulk of selenium to the estuary.

While selenium is the metal that poses the most known threat to aquatic species in the estuary, other metals such as copper and nickel are also being investigated for their potential effects on species. Dissolved copper concentrations are elevated in the estuary where its toxic effects are not buffered by organic ligands like in the more saline waters of the Bay (Werner et al. 2008). Nickel, primarily from urban runoff and wastewater treatment plants, may also have effects on species. Synthetic organometallic compounds such as Tributyltin (TBT), used in antifoulant paints for boats, is highly toxic to aquatic invertebrates (Werner et al. 2008).

Potential Activities during Phase 1 for the Delta and Suisun Planning Area (more detail available in Appendix E):

Diversion Effects of Pumps

- Continue participation in the Sacramento Valley/Delta Fish Screen Program, which seeks to reduce entrainment mortality of juvenile fish by installing state-of-the-art fish screens on Sacramento River and Delta diversions; includes collection of monitoring data prior to construction.
- Continue ERP coordination with State and Regional Water Quality Control Board, and IEP studies and activities geared toward determining the impacts of diversions on various life stages of fish.
- Further investigation of role of E/I ratio as dominant factor in particle fate, in relation to entrainment of pelagic organisms, including eggs and larvae, in SWP and CVP pumps and other diversions. (E/I ratio range of .17 to .35). Salmon smolts may not be accurately captured by this model because their behavior likely makes their fate depart substantially from neutrally buoyant particles such as pelagic species' eggs and larvae.

Non-native Invasive Species

- Continue implementing the CALFED NIS Strategic Plan, to prevent new introductions; limit spread or eliminate NIS populations through management; and reduce ecological, economic, social, and public health impacts of NIS infestation. Continue coordination activities, and hold training workshops on the HACCP program developed by UC Extension Sea Grant.
- Continue mapping of *Egeria* through funding to DBW's existing Egeria Densa Control Program.
- Continue research and monitoring to increase our understanding of the invasion process and the role of established NIS in ecosystems in the Delta and Suisun. Specifically:
    - Does *Egeria* or *Microcystis* invade newly restored sites? Conduct site-specific surveys to verify whether these NIS are present and spreading, and conduct water quality monitoring for parameters that could contribute to invasion by NIS (e.g. DO, temperature, salinity).
    - What is the potential role of alien jellies in relation to pelagic and planktonic fish? Are they increasing in abundance due to decline in other pelagic predators and greater prey availability, or are there confounding variables?
    - There is a hypothesis that recreating habitats that have a high variability in abiotic factors (e.g. salinity, channel flows and velocity, depth, water clarity) makes it unlikely that overbite and Asian clams, and *Egeria*, would be able to persist (e.g. annual exposure to freshwater for 3-6 months may limit Corbula's ability to invade areas).

- Continue study on effectiveness of localized treatment of zebra and quagga mussels using soil bacterium
- Continue investigation of potential parasite(s) to control invasive clam and/or mussel populations

Contaminants and Toxics

- Continue investigation into development of BMPs to control transport of methyl mercury from restored managed wetlands
- Possible assistance in Cache Creek Settling Basin effort to undertake improvements to reduce the amount of methyl mercury entering the Yolo Bypass and Delta.
- Characterize the impacts of upstream San Joaquin River algae loads on dissolved oxygen in the Stockton Deep Water Ship Channel
- Continue to coordinate with the State Water Resources Control Board and Central Valley and San Francisco Regional Water Quality Control Boards' comprehensive five-year strategic work plan for the Delta, including TMDL implementation and miscellaneous water quality studies.
- Participate in a comprehensive monitoring program, including collection and analysis of water quality data.
- Examine the relationships between contaminant exposure and organism effects, and the magnitude of these effects in terms of population impacts.
- Investigate the possibility of synergistic (rather than additive) impacts of multiple contaminants on species.
- Study and characterize the potential effects of ammonia on primary production and on aquatic species in the Delta.
- Conduct selenium research to fill data gaps in order to refine regulatory goals of source control actions, and determine bioavailability of selenium under several scenarios

Species

The Delta and Suisun Marsh support many species of native and nonnative fish, waterfowl, shorebirds, and wildlife. The ERPP describes conservation goals for these species. These conservation goals include: recovery (R), contribute to recovery (r), maintain (m), maintain harvest (H), and enhance and/or conserve (E) species associated with the Delta and Suisun Marsh (Table 2).

Table 1. Target Species in the Planning Area

Species	Sacramento-San Joaquin EMZ	Suisun Marsh EMU	ERP Designation
Delta smelt	X	X	R
Longfin smelt	X	X	R
Green sturgeon	X	X	R
Sacramento splittail	X	X	R
Winter-run Chinook salmon	X	X	R
Spring-run Chinook salmon	X	X	R
Fall-run Chinook salmon	X	X	R

Steelhead	X	X	R
Lange's metalmark butterfly	X	X	R
Valley elderberry longhorn beetle	X	X	R
Suisun ornate shrew		X	R
Suisun Song Sparrow		X	R
California Clapper Rail		X	r
California Black Rail	X	X	r
Swainson's Hawk	X	X	r
Salt marsh harvest mouse		X	r
Sacramento perch	X	X	r
Riparian brush rabbit	X		r
San Joaquin Valley woodrat	X		r
Greater Sandhill Crane	X		r
California Yellow Warbler	X	X	r
Least Bell's Vireo	X	X	r
Western Yellow-billed Cuckoo	X		r
Giant garter snake	X	X	r
Delta green ground beetle	X	X	r
Saltmarsh Common Yellowthroat		X	r
California freshwater shrimp		X	m
Hardhead	X		m
Western Least Bittern	X	X	m
California red-legged frog	X	X	m
Western pond turtle	X	X	m
California tiger salamander	X	X	m
Western spadefoot toad	X		m
Lamprey	X	X	E
White sturgeon	X	X	H
Mason’s lilaeopsis	X	X	R
Suisun Marsh aster	X	X	R
Suisun thistle		X	R
Soft bird’s-beak		X	R
Antioch Dunes evening-primrose		X	R
Contra Costa wallflower		X	R
Bristly sedge		X	R
Point Reyes bird’s-beak		X	r
Crampton’s tuctoria		X	r

Delta tule pea	X	X	r
Delta mudwort	X	X	r
Alkali milk-vetch		X	r
Delta coyote-thistle	X		r
Northern California black walnut	X	X	r
Rose-mallow		X	m
Eel-grass pondweed	X		m
Colusa grass		X	m
Boggs Lake hedge-hyssop		X	m
Contra Costa goldfields		X	m
Greene's legenere		X	m
Recurved larkspur	X	X	m
Heartscale	X	X	m

Potential Activities during Phase 1 in the Delta and Suisun Planning Area (more detail available in Appendix E):

- Chinook salmon: Constant Fractional Marking Program
- Delta smelt: refuge facility
- Population Biology, Life History, Distribution, and Environmental Optima of Green Sturgeon – Continue to conduct telemetric, physiological, reproductive, and genetic studies to provide managers with information on the size of its population and critical habitat, to inform development of a recovery plan.
- Continue to study current use and suitability of Delta for rearing by salmonids, particularly in newly restored tidal marsh areas (phase 1 & 2).
- Continue to study how much of salmonid mortality in the Delta is due to invasive species (predation by centrarchids and striped bass), diversions, low food availability, and/or cover supporting predatory fish, and competition by hatchery fish.
- Collect evidence on whether striped bass eat delta smelt (we know they eat salmon smolts, but don't know about smelt)

Drivers

There are a number of biological, physical, legal, and socioeconomic conditions that may present constraints to program implementation; these are discussed in Appendix D. In addition to these considerations, the ERP agencies recognize that potential changes in environmental conditions in the future can affect plant and animal species and their habitats. Potential threats include soil subsidence, sea level rise, change in climate and precipitation patterns, catastrophic events, invasive species and food web changes, upstream and in-Delta water development, upstream and in-Delta urbanization and population growth.

Many of these threats, termed "first-order drivers of change," were described by Mount et al. (2006) and are expected to influence future resource management in the Delta. For each of the six drivers, critical certainties and uncertainties have been identified for consideration within the context of various Delta planning efforts:

- Subsidence. Reclamation of marshes and wetlands in the historic Delta for agriculture has resulted in substantial subsidence of some islands, such that elevations of land in the central and western Delta are well below sea level. Subsidence of Delta islands is expected to continue as long as non-flooded agriculture remains the primary land use on areas with peat soil. Subsidence increases the differential between water surface elevation in channels and land elevation and increases instability of the levees protecting the islands. Flooded islands would be expected to reduce both water and habitat quality. Depth of subsided islands makes restoration of tidal freshwater marsh habitat very problematic, as quality of open water habitat on these deeply subsided islands would be expected to be low for native species.

- Sea Level Rise. Delta hydrodynamics are heavily influenced by tides, and sea level is a key determinant of tidal influence in the Delta. Global climate change is expected to increase sea levels and temperatures and affect local weather patterns. As sea level rises, intrusion of brackish water into the Delta is expected to increase; this intrusion of sea water would raise water surface elevations in the Delta, exacerbating the differential between water surface elevation in channels and land elevations in Delta islands. It is generally predicted that rising sea level will negatively affect Delta hydrodynamics and habitat conditions. A recent memo on sea level rise by the Independent Science Board (ISB) suggests that sea level rise this century is likely to be at least 70-100 cm, significantly greater (~200 cm) if ice cap melting accelerates (ISB 2007).

- Regional Climate Change. Global climate change influences local climate conditions, particularly temperature and precipitation patterns, with implications for future inflows from tributaries to the Delta. In California, changes in precipitation patterns (e.g. more rain and less snow) are expected to shift timing of tributary peak runoff from spring to winter. It is projected that extreme winter runoff events will become more frequent and intense, and freshwater inflows to the Delta in spring and summer will decrease; greater variations in flows between years are also expected. Cumulatively, these changes are expected to put additional pressure on the Delta's fragile levees and increase the intrusion of brackish water into the Delta, with corresponding declines in both water and habitat quality. In addition, modeling scenarios predict an increase in California's air temperatures in the range of 2-6° C in California (California Climate Change Center 2006). Because Delta water temperature is determined primarily by air temperature, this increase could exacerbate conditions for native aquatic species that are particularly sensitive to water temperatures. Finally, regional climate change also has the potential to increase the suitability of the Delta to invasions of new species and pathogens (e.g. West Nile virus, *Phytophthora* spp.).

- Catastrophic Events. The Delta is located in the vicinity of several active faults, with recent estimations of a 2-in-3 probability of a large magnitude earthquake within the next 30 years. Multiple levee failures and consequential island inundation could be anticipated. Depending on the season, water year, location ans size of the breech(s), flooding of subsided islands in the western and central delta would increase intrusion of brackish water into the Delta. This would result in short-term, and perhaps long-term changes in distribution, type, and quality of aquatic habitats.

- Invasive Species. Extensive invasion of the Bay-Delta estuary by non-native species has impacted ecosystem processes. Non-native species directly compete with natives for food, or have so significantly altered the food web that several native species are food-limited. Exotic plants and weeds have significantly changed native aquatic habitats by altering substrate, food/light availability, and/or water quality constituents (such as dissolved oxygen). Introductions of new invasive species are likely. Restoration activities will need to be monitored and adaptively managed in response to impacts on the Delta ecosystem.

- Urbanization and Population Growth. The Delta is surrounded by some of the most rapidly urbanizing areas in California. Urbanization has resulted in increased runoff to Delta waterways, and has increased infrastructure in the Delta that serves urban areas outside the Delta. Population growth in other areas of California is increasing demand for irrigation and drinking water supplies from the Delta. Rapidly growing demand for Delta resources may not be sustainable at current levels, and it will likely become increasingly difficult for resource managers to balance species needs in the future.

Incorporating threat considerations into a conservation strategy would require a risk analysis that could quantitatively assess uncertainties related to the threats. Uncertainties are difficult to assess, as they are complicated by randomness of events in nature and lack of knowledge (e.g. information, scientific understanding, and quantitative data). The ERP agencies are presently considering possibilities for conducting a risk analysis that would inform future updates to the ERP conservation strategy. It is expected that such an analysis would require a significant amount of time and funding to complete.

Implementation of the Conservation Strategy

The ERP Conservation Strategy will be implemented through the development of annual work plans that will guide funding decisions based on the priorities of restoring ecological processes, enhancing habitats, and reducing stressors. In the short-term, ERP will be using the DRERIP conceptual models and analytical framework to develop and evaluate potential ERP actions, and to evaluate potential actions that are being discussed in other planning forums.

Analytical Approach

The DRERIP effort has been preparing a suite of analytical tools for conducting scientific evaluations of potential ecosystem restoration actions and other resource management activities for the Delta. These tools, including conceptual models and an associated evaluation protocol, are well suited to evaluate potential actions at preliminary and in-depth levels. The conceptual models and evaluation protocol are scientifically robust and allow for transparency, standardization, and documentation of conservation decisions. Model outputs are useful for identifying the range of effects–positive and negative, intended and unintended, and gauging the magnitude, predictability, and reversibility of the effects. These tools also set the foundation for adaptive management by identifying where science needs reside and which actions are suitable for hypothesis testing. The conceptual models address habitats, ecological processes, species biology, and ecological stressors within the Delta region.

The fundamental approach to DRERIP modeling follows the driver-linkage-outcome (DLO) format, meaning deterministic models of ecosystem components linked together with cause-and-effect relationships of interacting variables and outcomes. It can be simplified into an overarching structure where ecological processes support specific habitat types, which in turn support species inhabiting the habitats. (Figure 7).

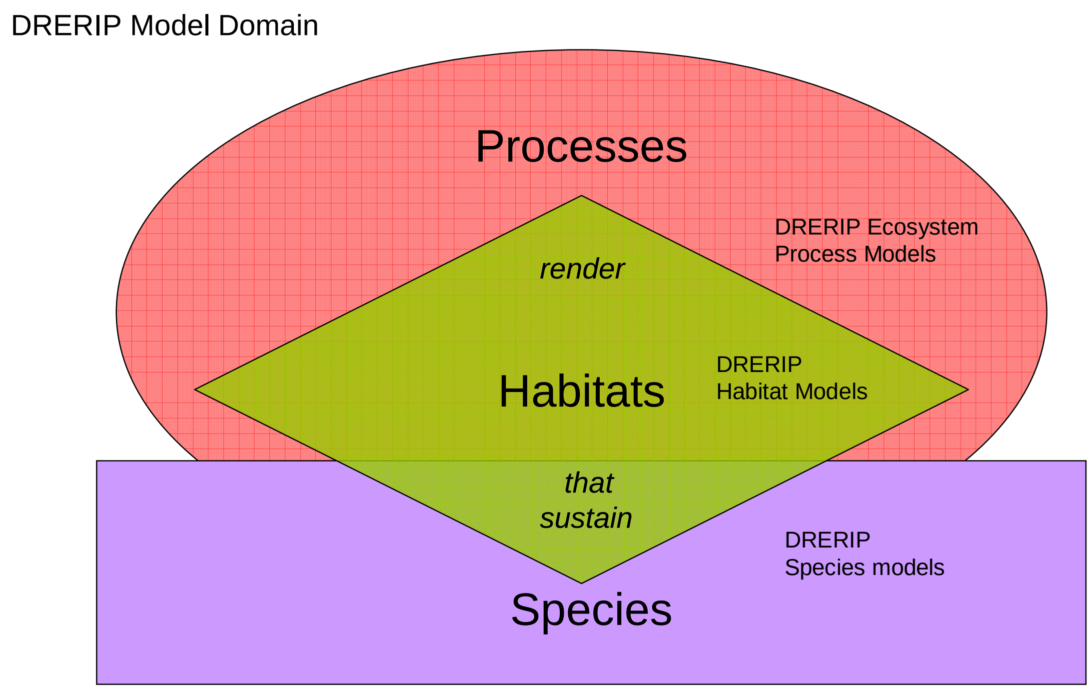


Figure 7. Ecological processes interact to support habitat types, which in turn support species using the habitats.

There are numerous drivers and intermediate outcomes leading to ultimate outcomes in a DRERIP analysis. Figure 8 provides an example where relationships of drivers, intermediate outcomes, and attributes are characterized through DLO chains leading to the ultimate outcomes of population viability and diversity.

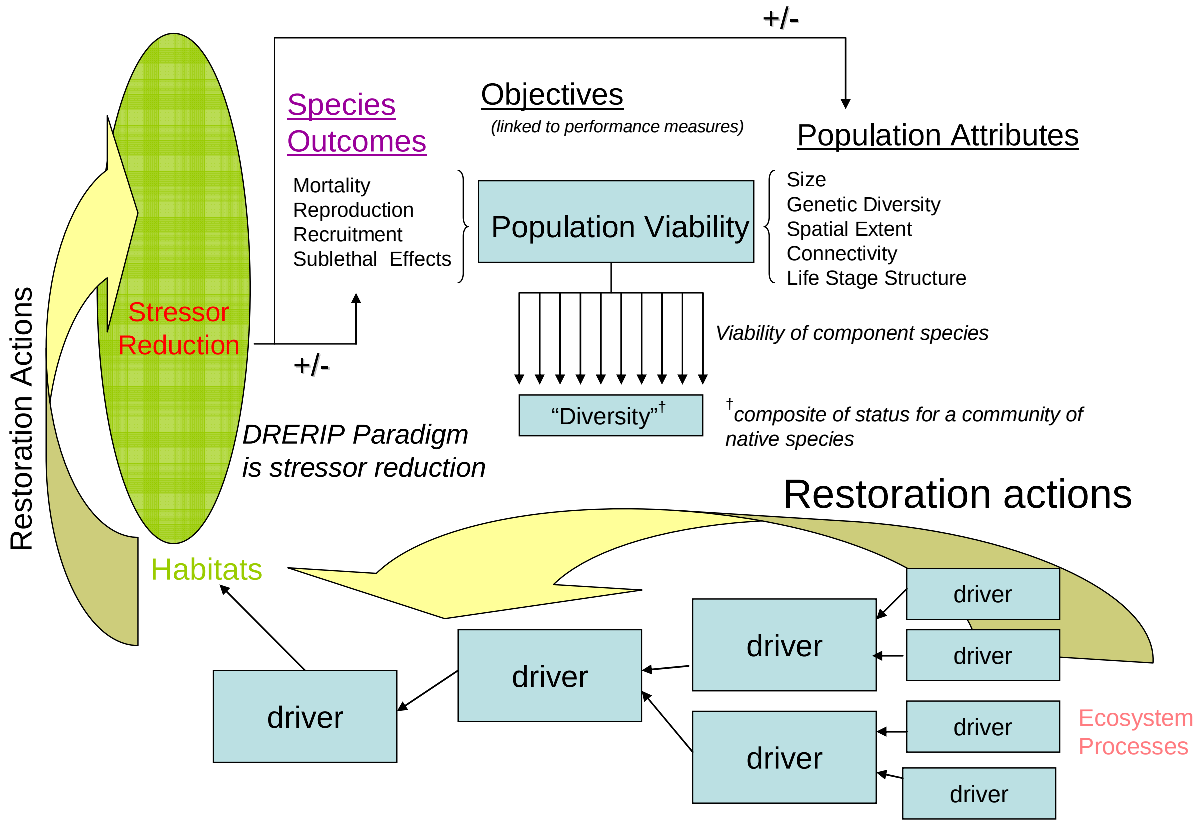
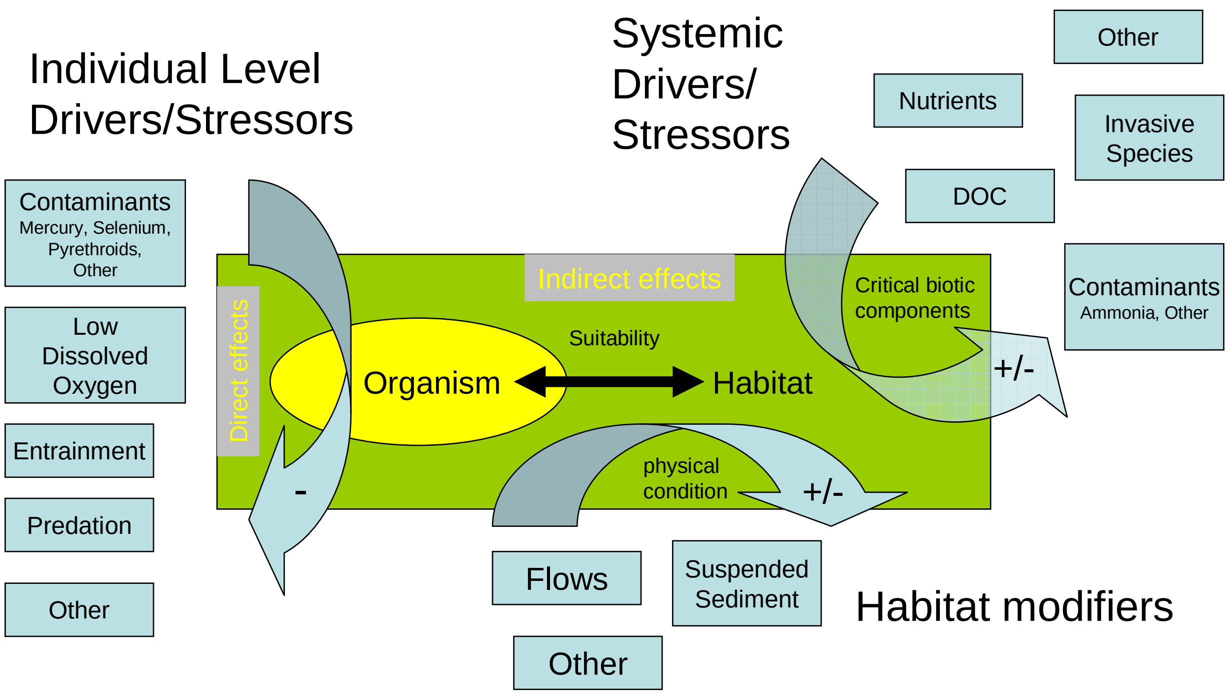


Figure 8. Restoration actions are directed to restore ecosystem processes, reduce stressors, and enhance habitats to achieve desired outcome of enhanced native species population viability and diversity.

Where the goal of restoration is to improve the status of species populations (e.g., recovery of at-risk native species), it is necessary to define species needs, and why these needs are not being adequately met. Review of species life history and associated stressors using DRERIP species models can help biologists surmise what habitat conditions may be limiting species populations. Restoration actions can then be developed and/or evaluated using DRERIP models for habitats, ecological processes, and stressors to determine the best approaches to restoration.

Restoration can be summarized as actions directed to increase habitat quality, quantity, and/or accessibility/connectivity. The habitat is acted upon by various indirect physical, chemical, and biological drivers that modify the basic infrastructure and render habitat suitability for component organisms. At the same time, certain direct stressors (e.g., acute toxicity, predation, and entrainment) act upon an organism inhabiting that particular habitat unit. Potential effects of restoration actions can be effectively assessed within a framework representing this overall species environment. The framework can be developed using groupings of environmental components contained within DRERIP conceptual models. Figure 9 portrays the relationship of an organism to its habitat (a dynamic process) using existing DRERIP models.



Modifiers affect underlying Baseline Features

Aquatic baseline example: depth, location, dissolved oxygen, temperature regime, salinity regime, extant biotic community, physical structure [referred to by Nobriga (2008) as stationary habitat attributes]

Figure 9. The relationship of an organism to its habitat using existing DRERIP models.

Use of conceptual models to improve understanding of the overall environment and the relationships of its components results in better predictability of the magnitude and certainty of the effects of potential restoration actions, including positive or negative effects that may or may not be anticipated, thereby providing for scientifically defensible courses of action for restoration and/or land and water management. Evaluation of potential restoration actions in this conceptual framework also helps to identify important gaps in data or ecological understanding, providing the opportunity for learning.

Future Direction in Conservation Strategy Development
The ERP implementing agencies will continue to refine the Conservation Strategy for the Delta and Suisun Planning Area periodically based on ongoing research and new information that becomes available, and with further evaluation of specific restoration actions. Comparable conservation strategies for other EMZs will be developed for the entire ERP focus area (Figure 1). It is anticipated that the ERP Conservation Strategy, as well as strategies developed for other EMZs in the ERP planning area, would be revisited and revised in accordance with new information, monitoring data, and updated conceptual models.

For the Delta and Suisun Marsh Planning Area, information will be incorporated into the strategy from other Delta-related planning efforts (e.g., Delta Risk Management Strategy, Suisun Marsh Implementation Plan, ERP End of Stage 1 Assessment, and Federally-listed species recovery plans) and technical and public input. In addition, the strategy will include actions that target species recovery. Areas proposed for restoration will be prioritized based on historical information that is currently being compiled and a ranking scheme generated in light of other criteria (such as cost, feasibility, durability, risk of urbanization, etc.).

Hydrologic criteria for wetlands and floodplains will be incorporated to reflect restoration needs. These criteria may include frequency, depth, and duration of flooding for floodplain and specific wetland types and management purposes. Marsh hydrology criteria from ongoing wetland management programs, such as Suisun Marsh and Yolo Bypass will be used.

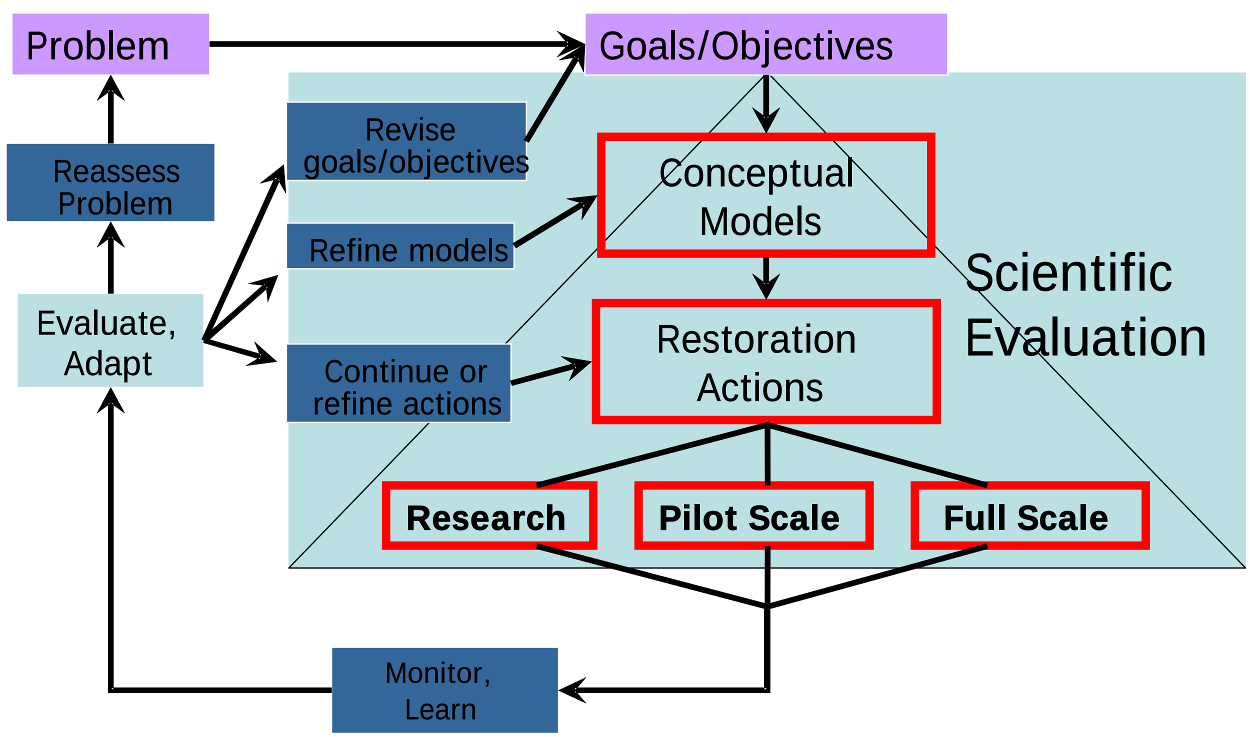
Funding
Some funding is available for ERP activities in the Delta and Suisun Planning Area in the near term from Propositions 84 and 13 and contributions from the Central Valley Project Improvement Act (CVPIA). These funds could be spent on actions in the Delta geared toward recovery of native Delta fish, or on actions to improve hydrodynamic and water quality conditions throughout the planning area. The availability of funding for implementation of restoration actions in the planning area in the future is uncertain, but some funding is expected to be provided as the Bay-Delta Conservation Plan is implemented in the future.

Governance
There is recognition that any long-term solution for the Delta to continue to accommodate both ecosystem and economic uses will include the creation of a governance structure that can implement that solution; these governance issues are currently under deliberation by the Delta Vision planning effort and the BDCP process. The ERP implementing agencies recognize that the outcome of these deliberations on governance will have some bearing on future implementation of the ERP in the Delta and Suisun Planning Area, but expect that the ERP will continue to be implemented primarily by the Department of Fish and Game, in close coordination with the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. It is expected that whatever overall governance structure is established for the Delta in the future, the ERP Conservation Strategy focused on the Delta and Suisun Planning Area will remain one specific component of the overall program for the Delta, with annual program plans and budgets being submitted to the governing entity through issue-specific public working groups. .

Adaptive Management, Performance Measures, and Monitoring

Due to uncertainties in the function of the Delta ecosystem, the effects of restoration and management actions cannot always be accurately predicted. Restoring and managing the Bay-Delta ecosystem requires a flexible framework that can generate and incorporate new information and adapt to changing conditions. Adaptive management provides such flexibility and opportunity for enhancing our understanding of the ecosystem. The adaptive management process identified in the ERP Strategic Plan (CALFED 2000c) provides a framework for adaptive management, which includes numerous assessments and feedback loops to ensure that management decisions are based on the best and most current information (Figure 10).

Figure 10. Adaptive Management Process (CALFED 2000c)



The ERP approach to adaptive management begins with defining clear goals and objectives and a management problem. Conceptual models (and possibly simulation models) will be used to derive anticipated responses to management options and address uncertainty. A model of system dynamics is always implicit in a restoration action designed to have certain consequences; it is critical to identify these implicit models and their consequences and examine any unintended outcomes in the process of planning for restoration (Healey 2001).

Specific management options should be designed and implemented in ways that allow system responses to be detected through monitoring. Monitoring is conducted based on the hypothesized system dynamics, and results are used to reassess the management options implemented and also to verify the accuracy of the conceptual models. Results are fed back into the management options development process to revise the options, or update the conceptual models, as necessary (Figure 10).

Adaptive management also incorporates scientific problem solving (experimentation) into management actions in a way that develops better resource management systems (Healey 2001; Walters 1986). The five steps of experimental protocol for adaptive management identified by CALFED (2000d) are:

1. Model the system in terms of current understanding and speculation about system dynamics (hypothesis development).
2. Design the management action to maximize benefits in terms of both conservation and information.
3. Implement management and monitor system response.
4. Update hypotheses based on new information.
5. Design new actions based on improved understanding.

The conceptual models underlying the hypotheses and management actions provide for a structured analysis of expected results by linking the actions to objectives through a set of logical cause/effect relationships (CALFED 2000c, Healey 2001). Conceptual models, thereby, provide a means to identify critical biological uncertainties, where monitoring and experimentation could be focused.

Conceptual models can be used in conjunction with performance indicators to help us understand whether actions lead to progress toward goals and objectives. Development and refinement of performance measures, a type of indicator, can establish measurable expectations of program performance (Healey 2001) and inform managers on program and policy decisions and future regulatory objectives, such as milestones. The ERP and the CALFED Science Program (and previously, the Comprehensive Monitoring, Assessment, and Research Program (CMARP)) have worked on ecosystem indicators and performance measures over the past 10 years, but it is recognized that a more comprehensive, robust, and accessible set of indicators and performance measures is needed (Science Program 2007).

Presently, needs for monitoring and performance measures are being addressed by ERP staff in conjunction with end of Stage 1 progress assessments and coordination with species recovery planning. Development of monitoring and performance measures will be linked with DRERIP conceptual models, which will inform ERP planners on ecological processes, habitats, stressors, and species life history. Following are basic guidelines, and critical steps associated with the translation of CALFED Program Goals and Objectives into quantitative performance measures:

<u>Define indicators and performance measures that meet Program objectives</u>.

1) Select indicators that reflect direct attainment of Program objectives (e.g., delta smelt fall midwater trawl index), or that reflect our best estimates of measures to meet these targets (e.g., limit entrainment of species Y to no more than X individuals within a defined time frame).

2) To the maximum extent practical, make these indicators quantitative and specific.

3) To the maximum extent practical, factor uncertainty into these indicators.

4) The target indicator can incorporate a safety margin associated with the defined performance measure, reflecting the degree of risk we are willing to accept, given the relative uncertainty we have with respect to the accuracy of the indicator (e.g. Is it really the Minimum Viable Population?), the uncertainty in our measurement, and future expectations with respect to changes within the system.

5) The working suite of models should be robust, peer-reviewed, and interlinked models that define state of the art scientific consensus regarding the functioning of the ecosystem with sufficient detail to include all principal factors driving ecosystem processes, yet simple enough to allow practical utility across disciplines. *(This task has been earlier identified as CMARP Task 2, but is currently being completed by DRERIP).*

6) The link to quantitative indicators from conceptual models requires quantitative (or semi-quantitative) models. *(The DRERIP conceptual models are the foundation for these.)*

7) Design and implement a monitoring program to address these quantitative indicators as defined by best available scientific knowledge. *(This task has been earlier identified as CMARP Task 3).*

8) Identify research needs from information gaps illustrated by the models. Prioritize research based on greatest need (e.g., information gaps that would address suspected limiting factors). *(This task has been earlier identified as CMARP Task 4).*

9) Refine and update models as research, monitoring, and assessment augment our knowledge of the ecosystem.

10) The link between conceptual understanding and adaptive management requires predictive models, so that results running counter to prediction can be utilized to refine our conceptual understanding towards a more reliable reflection of reality.

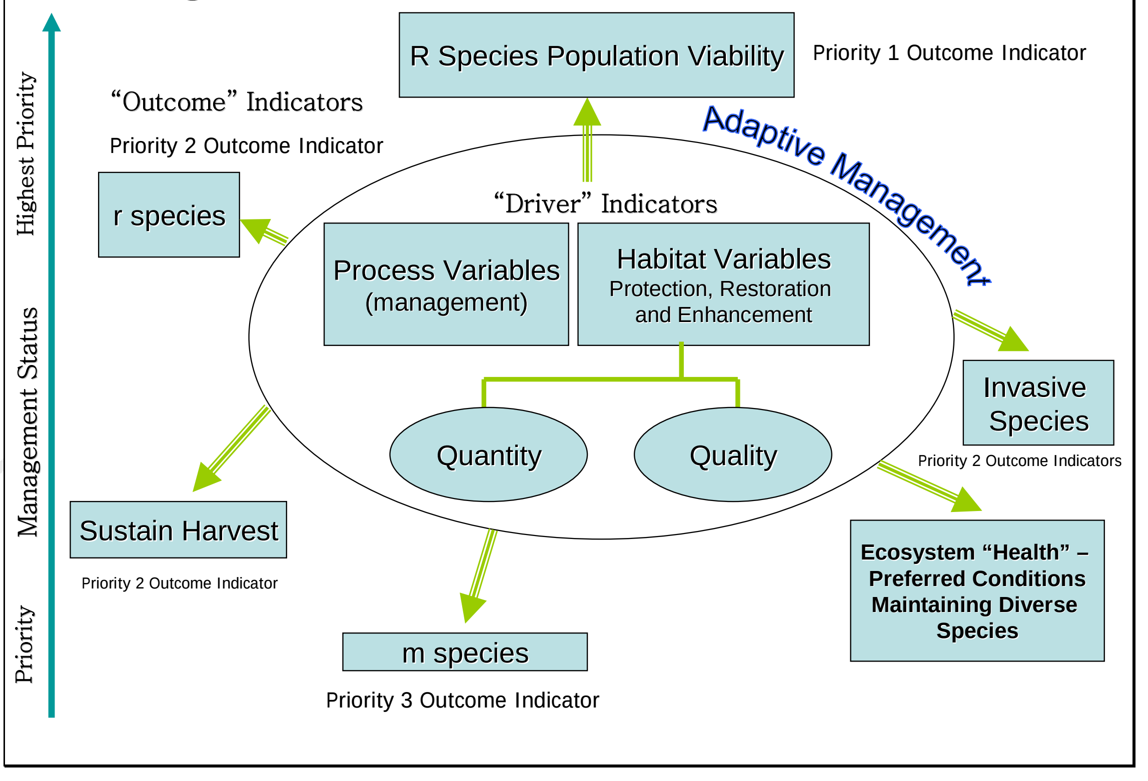
11) Program performance will be evaluated on a regular basis based on performance metrics.

12) In light of information gained through adaptive management, monitoring and assessment, performance measures will continually be evaluated and refined.

Figure 11 contains a structural diagram outlining the proposed framework under which ERP performance measures can be organized. The suggested approach involves the organization of the performance measures framework on two basic principles. The first of these is that the outcome of interest from a management perspective is the populations of given component species within the ecosystem. These component species have already been segregated based on conservation status and ecological overlap with the Delta (i.e., "R," "r," and "m" species). The status of each species represents the "outcome" indicators as expressed within the performance measures framework suggested by the CALFED Science Program (April 2006). These species can further be labeled primary, secondary, and tertiary outcome indicators based on their conservation priority (i.e. R, r, and m species, respectively).

The second basic organizing principle centers on the idea that populations of these outcome indicator species are determined in part by habitat conditions, including stressors, and processes influencing habitat. These variables would be considered "drivers" for species populations. These drivers identify a causal link associating individual events or attributes with a measurable response.

Figure 11: ERP Performance Measures Framework



The CALFED Science Program and Performance and Tracking Program are helping develop a performance measures framework and assisting in development of technical and communication products (Science Program 2007; ISB 2007). Ecosystem liaisons from the CALFED

Independent Science Board (ISB), in cooperation with the Science Program, are helping ensure scientific integrity.

The Adaptive Management Planning Team (AMPT) is currently completing life history/life cycle models for key CALFED species, including their ecological interactions (ecosystem models and stressor models). This process should identify the critical factors that dictate that species' population (stressors, or drivers; i.e., "limiting factors"). For each species, the key indicators of their population status would be defined, and the best metric(s) assigned as that specific outcome indicator. It is anticipated that the ERP Implementing agencies will, in cooperation with CMARP (and possibly with assistance from the Interagency Ecological Program), monitor population indicators and critical drivers. These data will be compared against models that will be refined and adapted as necessary.

This ERP activity will be coordinated with ongoing monitoring and planning activities of the Science Program, IEP (e.g., Delta monitoring and POD investigations), and other monitoring programs with overlapping restoration and monitoring interests (e.g., the CVPIA's Comprehensive Assessment and Monitoring Program (CAMP)).

ERP Science Standard

Like all CALFED programs, the ERP holds itself to a high standard of scientific integrity for development, review, and implementation of program activities. The ERP is integrating the best available science and peer review into every aspect of its program to guide decisions and evaluate actions that are critical to its success and effectual and prudent management of the Bay-Delta watershed by the responsible agencies. To ensure scientific integrity of developing, reviewing, and implementing its conservation strategy for Stage 2 of CALFED, the ERP is coordinating with the CALFED Independent Science Board (ISB), CALFED Science Program, DRERIP Adaptive Management Planning Team (AMPT), and the Interagency Ecological Program (IEP), among others, to obtain the most current data, most robust analytical tools, and soundest scientific oversight.

The ERP Implementing Agencies advocate the use of conceptual models as tools necessary to adequately understand the condition and function of ecological systems, assess potential actions that would affect ecological systems, and develop and implement prescriptions for ecosystem restoration and/or management. The conceptual models and evaluation protocol are scientifically robust and allow for transparency into the thought process, standardization, and documentation of conservation decisions. The conceptual models developed through the DRERIP process have undergone formal 'academic-level' peer review conducted by expert scientists. For more information, go to: www.delta.dfg.ca.gov/erpdeltaplan/. The ERP agencies have determined that the conceptual models and evaluation process developed through the DRERIP effort represent the acceptable scientific standard for ERP planning and implementation purposes, as well as the standard by which they would judge proposed activities by other entities affecting species and habitats under their purview.

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Appendix A - ERP Strategic Goals and Objectives

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

OBJECTIVE 1: Achieve, first, recovery and then large self-sustaining populations of the following at-risk native species dependent on the Delta, Suisun Bay and Suisun Marsh, with emphasis on Central Valley winter-, spring- and fall/late fall-run Chinook salmon ESUs, Central Valley steelhead ESU, delta smelt, longfin smelt, Sacramento splittail, green sturgeon, valley elderberry longhorn beetle, Suisun ornate shrew, Suisun song sparrow, soft bird's-beak, Suisun thistle, Mason's lilaeopsis, San Pablo song sparrow, Lange's metalmark butterfly, Antioch Dunes evening primrose, Contra Costa wallflower, and Suisun marsh aster.

OBJECTIVE 2: Contribute to the recovery of the following at-risk native species in the Bay-Delta estuary and its watershed: Sacramento perch, delta green ground beetle, giant garter snake, salt marsh harvest mouse, riparian brush rabbit, San Pablo California vole, San Joaquin Valley woodrat, least Bell's vireo, California clapper rail, California black rail, little willow flycatcher, bank swallow, western yellow-billed cuckoo, greater sandhill crane, Swainson's hawk, California yellow warbler, salt marsh common yellowthroat, Crampton's tuctoria, Northern California black walnut, delta tule pea, delta mudwort, bristly sedge, delta coyote thistle, alkali milk-vetch, and Point Reyes bird's-beak.

OBJECTIVE 3: Enhance and/or conserve native biotic communities in the Bay-Delta estuary and its watershed, including the abundance and distribution of the following biotic assemblages and communities: native resident estuarine and freshwater fish assemblages, anadromous lampreys, neotropical migratory birds, wading birds, shore birds, waterfowl, native anuran amphibians, estuarine plankton assemblages, estuarine and freshwater marsh plant communities, riparian plant communities, seasonal wetland plant communities, vernal pool communities, aquatic plant communities, and terrestrial biotic assemblages associated with aquatic and wetland habitats.

OBJECTIVE 4: Maintain the abundance and distribution of the following species: hardhead minnow, western least bittern, California tiger salamander, western spadefoot toad, California red-legged frog, western pond turtle, California freshwater shrimp, recurved larkspur, mad-dog skullcap, rose-mallow, eel-grass pondweed, Colusa grass, Boggs Lake hedge-hyssop, Contra Costa goldfields, Greene's legenere, heartscale, and other species designated "maintain" in the Multi-Species Conservation Strategy.

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

OBJECTIVE 1: Establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintain harvested species.

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

OBJECTIVE 3: Rehabilitate natural processes to create and maintain complex channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh.

OBJECTIVE 4: Create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.

OBJECTIVE 5: Establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery - and restoration of native aquatic and riparian species and biotic communities.

OBJECTIVE 6: Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats.

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

OBJECTIVE 1: Enhance fisheries for salmonids, white sturgeon, pacific herring, and native cyprinid fishes.

OBJECTIVE 2: Maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater game fishes.

OBJECTIVE 3: Enhance, to the extent consistent with ERP goals, populations of waterfowl and upland game for harvest by hunting and for non-consumptive recreation.

OBJECTIVE 4: Ensure that Chinook-salmon, steelhead, trout, rearing, and planting programs do not have detrimental effects on wild populations of native fish species and ERP actions.

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

OBJECTIVE 1: Restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include tidal marsh (fresh, brackish, and saline), tidal perennial aquatic (including shallow water and tide flats), nontidal perennial aquatic, tidal sloughs, mid-channel island and shoal, seasonal wetlands, riparian, shaded riverine aquatic, inland dune scrub, upland scrub, and perennial grasslands.

OBJECTIVE 2: Restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include riparian and shaded riverine aquatic, instream, fresh emergent wetlands, seasonal wetlands, other floodplain habitats, lacustrine, and other freshwater fish habitats.

OBJECTIVE 3: Protect tracts of existing high quality major aquatic, wetland, and riparian habitat types, and sufficient connectivity among habitats, in the Bay-Delta estuary and its watershed to support recovery and restoration of native species and biotic communities, rehabilitation of ecological processes, and public value functions.

OBJECTIVE 4: Minimize the conversion of agricultural land to urban and suburban uses and maintain open space buffers in areas adjacent to existing and future restored aquatic, riparian, and wetland habitats, and manage agricultural lands in ways that are favorable to birds and other wildlife.

OBJECTIVE 5: Manage the Yolo and Sutter Bypasses as major areas of seasonal shallow water habitat to enhance native fish and wildlife, consistent with CALFED Program objectives and solution principles.

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

OBJECTIVE 1: Eliminate further introductions of new species from the ballast water of ships into the Bay-Delta estuary.

OBJECTIVE 2: Eliminate further introductions of new species from imported marine and freshwater baits into the Bay-Delta estuary and its watershed.

OBJECTIVE 3: Halt the unauthorized introduction and spread of potentially harmful non-native introduced species of fish or other aquatic organisms in the Bay-Delta and Central Valley.

OBJECTIVE 4: Halt the release of non-native introduced fish and other aquatic organisms from private aquaculture operations and the aquarium and pet trades into the Bay-Delta estuary, its watershed, and other California waters.

OBJECTIVE 5: Halt the introduction of non-native invasive aquatic and terrestrial plants into the Bay- Delta estuary, its watershed, and other central California waters.

OBJECTIVE 6: Reduce the impact of non-native mammals on native birds, mammals, and other organisms.

OBJECTIVE 7: Limit the spread or, when possible and appropriate, eradicate populations of non-native invasive species through focused management efforts.

OBJECTIVE 8: Prevent the invasion of the zebra mussel into California.

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

OBJECTIVE 1: Reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health.

OBJECTIVE 2: Reduce loadings of oxygen-depleting substances from human activities into aquatic ecosystems in the Bay-Delta estuary and watershed to levels that do not cause adverse ecological effects.

OBJECTIVE 3: Reduce fine sediment loadings from human activities into rivers and streams to levels that do not cause adverse ecological effects.

Appendix B - Draft Species List for HCP/NCCPs in Delta and Suisun Planning Area

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	Suisun Marsh Aster, *Symphyotrichum lentum* (*Aster lentus*)	X		X				**CNPS 1B.2**
	Ferris's Milk-vetch, *Astragalus tener* var. *ferrisiae*	X						**CNPS 1B**
	Alkali Milk-vetch, *Astragalus tener* var. *tener*	X		X			X	**CNPS 1B.2**
	Heartscale, *Atriplex cordulata*	X		X				**CNPS 1B.2**
	Brittlescale, *Atriplex depressa*	X		X	X		X	**CNPS 1B.2**
	San Joaquin Spearscale, *Atriplex joaquiniana*	X			X		X	**CNPS 1B.2**
	Vernal Pool Smallscale, *Atriplex persistens*	X						**CNPS 1B.2**
	Big Tarplant, *Blepharizonia plumosa*				X			**CNPS 1B.1**
	Bristly Sedge, *Carex comosa*			X				**CNPS 2.1**
	Succulent Owl's Clover aka Fleshy Owl's Clover, *Castilleja campestris ssp. succulenta*			X				**Fed Threat** **CA Endang**
	Slough Thistle, *Cirsium crassicaule*			X				**CNPS 1B.1**
	Suisun Thistle, *Cirsium hydrophilum* var. *hydrophilum*	X						**Fed Endang** **CNPS 1B.1**
	Soft Bird's-beak, *Cordylanthus mollis* ssp. *mollis*	X						**Fed Endang** **CA Rare** **CNPS 1B.2**
	Palmate-bracted Birds Beak, *Cordylanthus palmatus*						X	**Fed Endang** **CA Endang** **CNPS 1B.2**
	Recurved Larkspur, *Delphinium recurvatum*	X		X	X			**CNPS 1B.2**
	Dwarf Downingia, *Downingia pusilla*	X				X		**CNPS 2.2**
	Delta Button-celery/Delta Coyote Thistle, *Eryngium racemosum*			X				**CA Endang** **CNPS 1B.1**
	Diamond-petaled (California) Poppy, *Eschscholzia rhombipetala*			X				**CNPS 1B.1**
	Fragrant Fritillary, *Fritillaria liliacea*	X						**CNPS 1B.2**
	Boggs Lake Hedge-hyssop, *Gratiola heterosepala*	X	X			X		**CA Endang** **CNPS 1B.2**
	Hogwallow Starfish, *Hesperevax caulescens*	X						**CNPS 4.2**
	Wooly Rose-mallow, *Hibiscus lasiocarpus*	X			X			**CNPS 2.2**
	Carquinez Goldenbush, *Isocoma arguta*	X						**CNPS 1B.1**
	Ahart’s Dwarf Rush, *Juncus leiospermus* var. *ahartii*					X		**CNPS 1B.2**
	Ferris’s Goldfields, *Lasthenia ferrisiae*	X						**CNPS 4.2**
	Delta Tule Pea, *Lathyrus jepsonii* var. *jepsonii*	X	X	X				**CNPS 1B.2**
	Legenere, *Legenere limosa*	X	X	X		X		**CNPS 1B.1**
	Heckard’s Pepper-grass, *Lepidium latipes var. heckardii*	X					X	**CNPS 1B.2**
	Mason′s Lilaeopsis, *Lilaeopsis masonii*	X		X				**CA Rare** **CNPS 1B.1**
	Delta Mudwort, *Limosella subulata*	X		X				**CNPS 2.1**
	Showy Madia, *Madia radiata*			X	X			**CNPS 1B.1**

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	Cotula Navarretia, *Navarretia cotulifolia*	X						CNPS 4.2
	Baker's Navarretia, *Navarretia leucocephala* ssp. *bakeri*	X						CNPS 1B.1
	Pincushion Navarretia, *Navarretia myersii* spp. *myersii*					X		CNPS 1B.1
	Adobe Navarretia *Navarretia nigelliformis* ssp. *nigelliformis*				X			CNPS 4.2
	Colusa Grass, *Neostapfia colusana*	X	X				X	Fed Threat CA Endang CNPS 1B.1
	Slender Orcutt Grass, *Orcuttia tenuis*		X			X		Fed Threat CA End CNPS 1B.1
	Sacramento Orcutt Grass, *Orcuttia viscida*		X			X		Fed Endang CA Endang CNPS 1B.1
	San Joaquin Valley Orcutt Grass, *Orcuttia inaequalis*	X						Fed Threat CA Endang CNPS G2/S2.1
	Gairdner's Yampah, *Perideridia gairdneri* ssp. *gairdneri*	X						CNPS 4.2
	Marin Knotweed, *Polygonum marinense*	X						CNPS 3.1
	Delta Woolly-marbles, *Psilocarphus brevissimus* var. *multiflorus*	X						CNPS 4.2
	Lobb's Aquatic Buttercup, *Ranunculus lobbii*	X						CNPS 4.2
	Sanford's Arrowhead (Sagittaria), *Sagittaria sanfordii*		X	X		X		CNPS 1B.2
	Side-flowering Skullcap, *Scutellaria lateriflora*			X				CNPS 2.2
	Rayless Ragwort, *Senecio aphanactis*	X						CNPS 2.2
	Wright's Trichocoronis, *Trichocoronis wrightii* var. *wrightii*			X				CNPS 2.1
	Saline Clover, *Trifolium depauperatum* var. *hydrophilum*	X						CNPS 1B.2
	Caper-fruited Tropidocarpum, *Tropidocarpum capparideum*			X				CNPS 1B.1
	Orcutt Grass (*Orcuttia viscida*)/Greene's Tuctoria, *Tuctoria greenei*			X				Fed Endang CA Rare CNPS 1B.1
	Crampton's Tuctoria (Solano Grass), *Tuctoria mucronata*	X					X	Fed Endang CA Endang CNPS 1B.1
ANIMALS	BIRDS							
	Cooper's Hawk, *Accipiter cooperii*	X		X		X	X	CA CSC
	Sharp-shinned Hawk, *Accipiter striatus*	X		X		X		CA CSC
	Western Grebe, *Aechmophorus occidentalis*			X				CA FGC
	Tricolored Blackbird *Agelaius tricolor*	X	X	X	X	X	X	CA CSC
	Bell's sage sparrow, *Amphispiza belli belli*			X				CA CSC
	Golden Eagle, *Aquila chrysaetos*	X		X	X	X		CA CSC
	Great Egret, *Ardea alba* (rookery)			X				CA FGC
	Great blue Heron, *Ardea herodias* (rookery)			X				CA FGC
	Short-eared Owl *Asio flammeus*	X				X	X	CA CSC
	Long-eared Owl, *Asio otus*					X		CA CSC

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	Burrowing Owl, *Athene cunicularia*	X	X		X	X	X	**CA CSC**
	Aleutian Canada Goose, *Branta hutchinsii leucopareia*		X	X				
	Ferruginous Hawk, *Buteo regalis*					X		**CA CSC**
	Swainson's Hawk, *Buteo swainsoni*	X	X	X	X	X	X	**CA Threat**
	Northern Harrier, *Circus cyaneus*	X				X	X	**CA CSC**
	Mountain Plover *Charadrius montanus*	X		X				**Fed Candit CA CSC**
	Western Yellow-billed Cuckoo, *Coccyzus americanus occidentalis*			X			X	**Fed Candit State Endang**
	California Yellow Warbler, *Dendroica petechia*						X	**CA CSC**
	White-tailed Kite, *Elanus leucurus*					X		**CA FP**
	Merlin, *Falco columbarius*					X		**CA FP**
	American Peregrine Falcon, *Falco peregrinus anatum*		X			X		**CA Endang CA FP**
	Salt Marsh Common Yellowthroat, *Geothlypis trichas sinuosa*	X						**CA CSC**
	Greater Sandhill Crane, *Grus canadensis tabida*		X	X		X		**CA Threat**
	Bald Eagle, *Haliaeetus leucocephalus*					X		**Fed Threat CA Endang**
	Yellow-breasted Chat, *Icteria virens*	X				X		**CA CSC**
	Loggerhead Shrike, *Lanius ludovicianus*		X			X	X	**CA FP**
	California Black Rail *Laterallus jamaicensis coturniculus*	X		X				**CA Threat**
	Suisun Song Sparrow, *Melospiza melodia maxillaris*	X						**CA CSC**
	White-faced Ibis, *Plegadis chihi*		X			X	X	**CA CSC**
	California Clapper Rail, *Rallus longirostris obsoletus*	X						**G5 S1**
	Bank swallow, *Riparia riparia*		X	X			X	**CA Threat**
	AMPHIBIANS							
	California Tiger Salamander, *Ambystoma californiense*	X	X	X	X	X	X	**Fed Endang CA CSC**
	Foothill Yellow-legged Frog, *Rana boylii*	X		X	X		X	**CA CSC**
	Western Spadefoot, *Spea hammondii*		X			X	X	**CA CSC**
	REPTILES							
	Western Pond Turtle, *Actinemys marmorata*	X	X	X	X	X	X	**CA CSC**
	Silvery Legless Lizard, *Anniella pulchra pulchra*				X			**CA SCS**
	San Joaquin Whipsnake, *Masticophis flagellum ruddocki*			X				**CA CSC**
	Alameda Whipsnake, *Masticophis lateralis euryxanthus*				X			**Fed Threat CA Threat**
	Giant Garter Snake, *Thamnophis gigas*	X	X	X	X	X	X	**CA Threat**
	MAMMALS							
	Pallid bat, *Antrozous pallidus*					X		**CA CSC**
	Ringtail, *Bassariscus astutus*					X		**CA FP**
	Townsend's Western Big-eared Bat, *Corynorhinus townsendii townsendii*				X			**CA CSC**
	Western Red Bat, *Lasiurus blossevillii*					X		**CA CSC**

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	Yuma Myotis Bat, *Myotis yumanensis*					X		**CA CSC**
	Riparian Woodrat, *Neotoma fuscipes riparia*			X				**Fed Endang CA CSC**
	Salt Marsh Harvest Mouse, *Reithrodontomys raviventris halicoetes*	X						**Fed Endang CA Endang**
	Suisun Shrew, *Sorex ornatus sinuosus*	X						**CA CSC**
	Riparian Brush Rabbit, *Sylvilagus bachmani riparius*			X				**Fed Endang CA Endang**
	American Badger, *Taxidea taxus*					X		
	San Joaquin Kit Fox, *Vulpes macrotis mutica*			X	X			**Fed Endang CA Threat**
	INVERTEBRATES							
	Ciervo Aegialian Scarab Beetle, *Aegialia concinna*			X				**G1 S1**
	Conservancy Fairy Shrimp *Branchinecta conservatio*	X	X	X	X		X	**Fed End**
	Vernal Pool Fairy Shrimp, *Branchinecta lynchi*	X		X	X	X	X	**Fed Threat**
	Longhorn Fairy Shrimp, *Branchinecta longiantenna*		X	X	X			**Fed Endang**
	Mid Valley Fairy Shrimp *Branchinecta mesovallensis*	X	X	X	X	X	X	**G2 S2**
	Valley Elderberry Longhorn Beetle *Desmocerus californicus dimorphus*	X	X	X		X	X	**Fed Threat**
	Delta Green Ground Beetle, *Elaphrus viridis*	X						**Fed Threat**
	Curved-foot Diving Beetle, *Hygrotus curvipes*			X				**G1 S1**
	Ricksecker's Water Beetle, *Hydrochara rickseckeri*	X				X		**G1G2 S1S2**
	Vernal Pool Tadpole Shrimp, *Lepidurus packardi*	X	X	X	X	X	X	**Fed Endang**
	Callippe Silverspot Butterfly, *Speyeria callippe callippe*	X						**Fed Endang CA Endang**
	FISH							
	Green Sturgeon, *Acipenser medirostris*			X				**CA Threat**
	Delta Smelt, *Hypomesus transpacificus*	X		X				**Fed Endang CA Candit End**
	Chinook Salmon - Winter-run, *Oncorhynchus tshawytscha*	X						**FED Endang CA Endang**
	Chinook Salmon-Central Valley fall/late fall-run ESU, *Oncorhynchus tshawytscha*	X						**Fed SC**
	Chinook Salmon - Spring-run, *Oncorhynchus tshawytscha*	X						**Fed Threat CA Threat**
	Steelhead - Central Valley ESU, *Oncorhynchus mykiss*	X						**Fed Threat**
	Sacramento Splittail, *Pogonichthys macrolepidotus*	X		X				
	Longfin Smelt, *Spirinchus thaleichthys*			X				**CA Threat**

Appendix C - Habitat Crosswalk

The following table provides a crosswalk between habitat categories in the ERP conservation strategy map for the Delta and Suisun Planning Area and those in the ERP Plan (2000).

	Subsided Lands	**Intertidal**	**Floodplain**	**Uplands**	**Grassland/ Vernal Pool Transition Corridor**	**Water**
Tidal Perennial Aquatic Habitat		X	X			X
Nontidal Perennial Aquatic Habitat			X	X		X
Delta Sloughs (dead-end)		X				
Delta Sloughs (open-ended)		X				
Mid-channel Islands and Shoals		X				
Saline Emergent wetland		X				
Fresh Emergent Wetland	X	X	X			
Seasonal Wetlands	X		X	X	X	
Riparian and Shaded Riverine Aquatic Habitats			X	X	X	
Riparian and Riverine Aquatic Habitats (scrub, woodland, forest)		X	X	X	X	
Freshwater Fish Habitats		X	X			X
Essential Fish Habitats		X	X			X
Inland Dune Scrub Habitat				X		
Perennial Grassland			X	X	X	
Agriculture Lands (wetlands)	X					
Agriculture Lands (uplands)	X					

Appendix D - Constraints

Considerations and Possible Constraints to ERP Implementation

Several constraints exist when faced with building a preserve system. The acquisition of parcels are carefully evaluated to determine it's biological value to individual target species and its contribution to the preserve design system as a whole. The following summarized consideration in that analysis.

Biological
Basic biologic and ecological functions: Does the area provide breeding, foraging, nesting, refugia and other suitable habitat for target species?

Commensal relationships: Species exist within an ecological web which include but may not be limited to food availability, predators, pollinators, and symbiotic relationships. Habitat most important to a species' survival must include several interacting variables.

Non-native Invasive Species: Some non-native species alter their new habitat such that the entire ecosystem upon which the native species depend is altered, and the native species are impacted if not displaced and locally extirpated. If non-native invasives are present on a parcel, ongoing management costs increase dramatically.

Genetics: Does the preserve contain a sustainable number of individuals or provide adequate gene flow with other areas to sustain the population?

Linkage: The target species may have limited mobility or require several habitat types within close proximity (e.g. tiger salamander need unimpeded access from its wetland breeding habitat to upland refugia). Others may require migratory corridors between summer and winter ranges. Linkage between core preserve areas with appropriately sized corridors is very important. Because these corridors frequently increase an "edge-effect" which increases predation, appropriate buffer habitats around the corridors is optimal.

Ecologically appropriate habitat scales: A preserve system must contain microhabitats necessary to sustain target species, provide for movement, linkage, genetic flow, recolonization, and be large enough to support landscape-level functions.

Physical
Soils: The soil type must be appropriate to support the desired habitat type. An example would be that wetland restoration would require hydric soils. Some plant and animal species also require a narrow range of soil types to survive.

Hazardous waste materials: Every potential land acquisition requires a preliminary survey for the presence of hazardous waste materials, the results of which may eliminate a parcel from consideration or significantly increase the management cost for removal and remediation.

Water: The water source, abundance, timing of flows, upstream uses (sewage outfall, mining operations, hydropower structures) and rights (riparian and instream), instream needs, wetland requirements for inundation period and depth, barriers (dams, culverts), diversions (unscreened pumps, agricultural ditches), groundwater and springs (over-draft, diverted, contamination) all affect a parcel's applicability within a preserve system, as well as the cost of restoration, operations and management.

Buffers: Buffers should be acquired between preserve lands and urban development to reduce impacts from urban disturbance such as light and noise, and facilitate preserve management practices such as limiting use of burning. Buffer width will vary depending on the preserve habitat sensitivity and species needs.

Edge: Optimal preserve design systems reduce the edge or interface between preserve land and other land uses. A large contiguous preserve area reduces management costs as well as optimizing species needs for minimum- sized habitat blocks.

Environmental Gradients: The preserve should include a range of environmental gradients such as topography, hydrology, and aspects to allow for environmental variation such as variety of seral stages and changes expected from global warming.

Carrying Capacity: The preserve should include suitable but unoccupied habitat in order to support increased species numbers and aid in recovery.

Legal-Political

Floodway easements: Large and small floodways have individual needs with regard to conveying floodwaters. Conflicts may arise when the floodways are established to protect adjacent personal property such as orchards and homes. However, the need for creating "natural" floodways and floodplains has become increasingly important for the survival and recovery of several native plant and animal species, notably Chinook salmon and steelhead. Optimally, preserve floodways will be located in areas which provide seasonally flooded habitat while protecting private property, as well as health and safety values.

Private Property Rights: The continued protection of private property from preserve activities will be evaluated in each acquisition, and addressed in the preserve's management plan. Items to be addressed would include but not be limited to the prevention of seepage from created wetlands to adjacent private property, safe harbor for listed species, and fuel load reduction in buffer areas. As stated elsewhere in this document, all acquisition will occur on a "willing-seller" basis.

Multi-agency jurisdiction: Local, state and federal land-use designations all interplay to determine an area's highest and best use. Basin plans, conservation areas, floodplain designation, prime agricultural soils designations) Delta Risk Management Strategy Infrastructure and levee stability analysis

Regulatory

- Various Farm Bills
- Lake or Streambed Alteration Agreements
- Clean Water Act
- California Coastal Act
- California Environmental Quality Act
- National Environmental Policy Act
- California Endangered Species Act
- Federal Endangered Species Act
- Federal Insecticide, Fungicide, and Rodenticide Act
- National Historic Preservation Act
- National Pollutant Discharge Elimination System permits
- County Regulations regarding burning, pesticide regulations, grading ordinances, agriculture preservation regulations, and zoning

Public Use and Access

Most state funds which are provided by taxpayers require a level of public benefit or use, including recreational, research and educational uses, as part of the management strategy. Remote areas with access frequently attract trash dumping which increase management costs. Illegal human activities can occur in both remote and accessible properties. Appropriate and adequate signing is usually necessary to enforce preserve restrictions.

Land use

Overlying land-use designations, zoning, etc.
Existing HCP/NCCP's covering area
Local concerns for loss of farmland when agricultural parcels are restored to habitat
Overlying easements for access, floodwater passage, emergency vehicles, etc.

Cultural

Management of areas with historical or cultural artifacts, burial sites, etc. must be handled in a manner which meets state, federal and tribal laws

Economic

A durable funding source is necessary for preserve activities including:

- Cost of Land
- Purchasing ccess easements
- Maintenance of infrastructure-pumps, fences, access roads, levees, firebreaks, drains, etc.
- Hazardous materials and spill prevention plan should be prepared for each preserve.

- Agricultural lands managed in a "wildlife friendly" manner would increase costs since this management strategy usually includes constraints on plowing, mowing, harvest periods, herbicide use and habitat set-aside.
- Cost of water pumping and/or acquisition of water rights
- Taxes and in-lieu fees
- Long-term durable funding stream for management usually requires a protected interest-bearing account.

Management

- Active restoration and management would cost more than passive methods but may be necessary to accelerate, monitor and direct the restoration process
- Restoration of highly degraded habitat or conversion of out-of-kind habitat would require additional costs
- Fuel load reduction
- Control of weeds and other invasive exotic species (some methods such as grazing and prescribed burning may not be feasible in urban areas).
- Recreational uses would increase management costs from trash pick-up, trail and parking lot maintenance and human waste management.
- Controlling access to mines and abandoned structures that may create a hazardous and/or dangerous attractive nuisance. This becomes increasingly important when these areas provide habitat for target species such as bats.
- Herbicide Use.
- Grazing and other Agricultural uses.
- Prescription burning is frequently used as a management tool to reduce fire load, control invasive species, and provide high temperature fire adapted plant species.
- Vector Management.
- Fencing construction.
- Buffer area establishment.

Monitoring and Adaptive Management

Very remote, isolated preserves, and those parcels with extreme terrain are more difficult to monitor on a regular basis and increase monitoring costs. Scientifically and statistically valid monitoring to determine success in meeting preserve goals for species and habitat restoration is extremely expensive, and may be the most costly item in budgeting for preserve management costs

Appendix E - Progress in Reducing the 12 Uncertainties during ERP Stage 1 in the Delta and Suisun Planning Area

1. Non-Native Invasive Species

Non-native invasive species (NIS) have produced immense ecological changes throughout the Bay-Delta ecosystem, and they represent one of the biggest impediments to restoring populations of native species (CALFED Bay-Delta Program 2000). To minimize the risk of potentially massive ecological and biological disruptions associated with non-native species, CALFED established the Non-Native Invasive Species program in 1998, which developed both a Strategic Plan and an Implementation Plan for addressing non-native invasive species in the Bay-Delta ecosystem. The goals of the program are the following:

- Prevent new introductions and establishment of NIS into the ecosystems of the Bay-Delta, the Sacramento/San Joaquin rivers and their watersheds.
- Limit the spread or, when possible and appropriate, eliminate populations of NIS through management.
- Reduce the harmful ecological, economic, social, and public health impacts resulting from infestations of NIS through appropriate management.
- Increase our understanding of the invasion process and the role of established NIS in ecosystems in the CALFED region through research and monitoring.

The following is a brief description of activities that have been implemented during CALFED Stage 1. The Non-native Invasive Species Advisory Council (NISAC) is responsible for the coordination and implementation of activities and projects that address the issues of NIS in the CALFED area of concern. The NISAC is also promoting an invasive species prevention approach known as Hazard Analysis and Critical Control Points planning or HACCP (http://www.haccp-nrm.org). HACCP is a planning tool that identifies and evaluates potential risks for introducing "non-targets," such as invasive species, chemicals, disease, and other undesirables, during routine activities. Reducing the Risk of Importation and Distribution on Nonindigenous Invasive Species Through Outreach and Education project developed a series of directed educational products and services that that brought together experts in NIS biology with members and representatives of a wide range of industries that may potentially be involved in the importation, sales, or distribution of NIS. The Water Hyacinth Education Program distributed educational materials to Delta residents. The Reducing the Introduction and Damage of Aquatic Nonindigenous Species through Outreach and Education, Phase 2 program worked to prevent future invasions by educating industries involved in the sales and distribution of non-native species including the aquaria and pet trade, seafood importers, landscape contractors, nurseries and aquatic plant dealers, seafood importers, bait dealers, and others, about the costs and consequences of unwanted introductions. The Practical Guidebook to Prevent and Control Non-native Invasive Plants in Shallow Water Habitats of the Bay-Delta Ecosystem provides information for local control of the highest priority species of non-native invasive plants in shallow water habitats of the landscape of the Bay-Delta watershed.

The San Francisco Regional Water Quality Control Board has determined that ballast discharge is a form of pollution (biological pollution) under the CWA. A 2005 federal court ruling defined non-indigenous species as "pollutants" present in discharges from vessels and found that such discharges are not exempt from permitting requirements (NPDES). Some regional boards placed specific water bodies within their regions on the CWA 303(d) list as impaired by exotics. San Francisco Bay was listed in 1998. In 2006, the State Water Resources Control Board (SWRCB) considered listing proposals for the Delta, the upper San Joaquin River, and the Cosumnes River. Once on the 303(d) list, the regional boards must develop programs for managing pollutant loads, but it has been difficult to establish TMDLs for exotic species (Resource Agency 2007).

In 2006 CDFG released a draft of the "California Aquatic Invasive Species Management Plan (CAISMP)." Following public review and input from other agencies, constituent groups, NGO's and academia, the plan was finalized and signed by the governor in January of 2008. The main purpose of the plan is to coordinate efforts by state agencies to minimize the harmful ecological, economic and human health impacts of aquatic invasive species. The plan proposes management actions and a rapid response process for addressing aquatic invasive species (AIS) threats to California. It focuses on the non-native algae, crabs, clams, fish, plants and other species that continue to invade California's creeks, wetlands, rivers, bays, and coastal waters (CDFG 2008). It provides a framework to respond to AIS in California, and protect the biological integrity of native plant and animal communities. The Objectives for the Plan identified during stakeholder meetings are as follows: Coordination and Collaboration, Prevention, Early Detection and Monitoring, Rapid Response and Eradication, Long-term Control and Management, Education and Outreach, Research and Laws and Regulations. The plan also recognizes monitoring efforts by CSLC, DFG/OSPR, and CDFA, and identifies gaps in the current programs. The Plan identifies lead and cooperating agencies for each action within these objectives and sets up a timeline for completing actions and for revisions to the plan. The Plan also includes a draft Rapid Response Plan that provides generic guidance for agencies responding to suspect infestations. The recent quagga mussel incident will be used as a case study on how aspects of the plan have been implemented. Aquatic Nuisance Species Task Force (ANSTF) conditionally approved the CAISMP. The ANSTF is an intergovernmental organization dedicated to preventing and controlling aquatic nuisance species, and implementing the Nonindigenous Aquatic Nuisance Prevention and Control Act (NANPCA) of 1990.

The Arundo donax Eradication and Coordination Program (ACEP) which is administered for Team Arundo del Norte (TAdN) by the Sonoma Ecology Center (SEC). The purpose of the program is to coordinate and assist in the planning and implementation of Arundo eradiation projects in the Sacramento-San Joaquin River and Bay-Delta region. This project directed funds to several watersheds (including Putah Creek, Big Chico Creek, Napa River, American River, San Joaquin River, and Cache Creek) to carry out Arundo eradication. Arundo donax Eradication and Coordination Program: Monitoring and Evaluation when funded will implement the monitoring of Arundo eradication sites for restoration success. California State University, Chico Research Foundation, identified and initiated eradication of areas infested by Arundo and tamarisk on Red Bank Creek, and Reed's Creek. The CDFA Purple Loosestrife Control Project continues to implement prevention, detection, and control of purple loosestrife in the CALFED Bay-Delta Watershed. They are currently accomplishing this by spraying with Glyphosate herbicide twice per year. In 2007, CDFG completed the eradication of Northern Pike (Esox lucius) from Lake Davis, on the Feather River. If the northern pike had escaped Lake Davis, they would likely have had a great effect on Central Valley fish including a number of species whose populations have already declined significantly (Chinook salmon, steelhead, delta smelt, and splittail).

ERP and other entities have and continue to fund NIS research projects. The life history patterns and competitive strategies of *Egeria densa* growing in the Delta was investigated. Growth rates, photosynthetic responses and nutrient content of *E. densa* were measured from plants collected in Disappointment Slough. Plants did not senesce during the study period. *E. densa* stem fragments were floated for 11 weeks, 100% of the stems survived and 50% successfully rooted. The survival and success of E. densa stem fragments reinforces the need to remove fragments after harvesting.

Mapping of invasive plants is necessary for monitoring their spread and to direct treatment. The California Department of Boating and Waterways (CDBW) is the lead agency for the survey and control of Egeria (*Egeria densa*) and water hyacinth (*Eichhornia crassipes*) in the Sacramento/San Joaquin Delta. *E. densa* now covers approximately 12,000 acres or 24% of the Delta (Newman 2006). It has been growing at a rate of approximately 1,000 acres per year. Water hyacinth covers approximately 5,000 acres or 10% of the Delta and grows exponentially during the hot summer months (Newman 2006). The DBW *Egeria* and water hyacinth programs use two tools to determine the coverage and bio-mass of these invasive species: hyperspectral analysis and hydroacoustic measurements. Hydroacoustic plant mapping technology has aided in the assessment of Brazilian waterweed coverage and biovolume which has proven instrumental in evaluating efficacy of treatment by CDBW (Ruch and Kurt 2006). A key asset of the technology is that it yields a very rapid, verifiable characterization of the entire water column beneath the transducer (Ruch and Kurt 2006). EDCP efforts may not result in successful and complete vegetation restoration of in waterways due to the presence of other non-native invasive aquatic weeds (CDBW 2006). Other non-native species that could fill in, and grow to replace *Egeria densa* as it is controlled by the EDCP include, among others, *Myriophyllum spicatum* (Eurasian Watermilfoil) and *P. crispus* (Curlyleaf Pondweed). These other, non-*Egeria*, nonnative species have different growth properties that may require other control approaches and techniques than those used by the EDCP (CDBW 2006).

Phragmites australis is considered the most invasive plant in marsh and wetland communities in the United States. *Phragmites* is a cryptic invader. Because of the difficulty in detecting them, cryptic invaders are a largely unrecognized type of biological invasion that lead to underestimation of the total numbers and impacts of the invaders. The distribution and abundance of *Phragmites* in North America has increased dramatically over the past 150 years. Saltonstall (2002) showed that a non-native strain of *Phragmites* is responsible for the observed spread, including in California. Rudrappa et al. (2007) found the root exudates of exotic were more effective in causing root death in susceptible plants compared to the native exudates. The active ingredient in was identified as 3,4,5-trihydroxybenzoic acid (gallic acid). Gallic acid demonstrated an inhibitory effect on *Spartina alterniflora*, one of the salt marsh species it successfully invades.

Environmental Science Associates developed a GIS map of this region-wide inventory researched the distribution of perennial pepperweed in the Bay-Delta. Areas predicted to be at high risk include the north part of Suisun Bay and around Grizzly Bay, Petaluma River, and Napa-Sonoma marshes. Possible limitations due to competition, salinity levels or water inundation all need further exploration. UC Davis researchers examined the invasion dynamics of perennial pepperweed, and their consequences for the protection of wetlands in the San Francisco Estuary. The research revealed the major interactions affecting perennial pepperweed colonization and should help define nuanced programs of control that may minimize pepperweed without destroying the native vegetation. Results showed that perennial pepperweed density was significantly reduced by increased levels of salinity and soil moisture. Increased salinities decrease the reproductive potential during seed production and reduce the germination success and viability of the seed. Seeds collected from the fresh and brackish sites, exhibited high rates of germination in low salinity treatments, but when salinities exceeded 15% germination was suppressed. Furthermore, results showed that recruitment was generally negatively correlated with increasing salinity at the defined developmental stages (i.e. cotyledon, two-leaf, four-leaf, small rosette, large rosette, and stem). Within the salinity-induced decreased recruitment response, bare ground and infrequent flooding provided the most suitable conditions for recruitment. At all sites, perennial pepperweed played an important role in displacing other native wetland species in tidal marshes, and may facilitate future colonization by other nonnative species. Glyphosate has been routinely used to control perennial pepperweed in the San Francisco Estuary, but it is uncertain how effective control treatments have been in tidal marshes. The CDFG has demonstrated effective treatment of perennial pepperweed with chlorsulfuron (Estrella 2007).

Small (2007) conducted a study to examine factors affecting landbird demographics in the context of floodplain forest restoration in an agricultural valley. Nest predation rates on restoration and mature remnant forest sites did not differ, indicating that restoration sites are functioning at least as well as forest sites as breeding habitat, in terms of nest success.

With respect to fouling, Falkner et al. (2007) offered the following questions as critical for the development of effective scientifically grounded management requirements. At a minimum, information is needed to address the most basic, but most important question: How many fouling organisms and how many NIS arrive to and move within California via vessel fouling? Such information is critical for a characterization of the NIS risk faced by California. When coupled with vessel maintenance and movement patterns linked to fouling accumulation, research would lay the foundation to fill additional information gaps such as which kinds of vessels harbor notably more fouling organisms than others, what criteria can be used to flag a potentially high risk vessel, and which vessels pose a negligible amount of risk. Answers to these kinds of management-based research questions can guide the formulation of preventative management actions in the future.

Schroeter and Moyle (2007) are currently investigating the ecology of alien invasive jellyfish, (*Maeotias marginata*, *Moerisia* sp., *Blackfordia virginica*, *Cordylophora caspia*), all of which are now commonly captured in the upper San Francisco Estuary. Preliminary results reveal a high seasonal catch of *Moerisia* sp., a moderate catch of *M. marginata*, and a low catch of *B. virginica* medusae (Schroeter and Moyle 2007). Invasive hydrozoan jellyfish are potentially contributing to the decline and/or recovery failure of plankivorous fishes in the upper San Francisco Estuary (Wintzer and Moyle 2007). Schroeter and Moyle (2006) have presented the following conclusions/questions for further research:

- *Maeotias* are increasing in abundance in the San Francisco Estuary, especially in the last 5 years.
- Salinities ranging between 2–10 ppt and temperatures >19 °C are facilitating large blooms.
  - Late summer water export and reduced outflow is a strong catalyst for a bloom to occur upstream of the Carquinez Straits (Grizzly Bay and Suisun Bay and Marsh).
  - Diet suggests potential for competition through resource overlap with other pelagic organisms such as fishes given Summer and Fall prey resources are limited in the San Francisco Estuary.
- Predation on native fishes is limited due to a temporal mismatch. Non-natives may be vulnerable, especially gobies.
- Are *M. marginata* increasing in abundance due to decline in other pelagic predators and greater prey availability or are other things going on?

The Asian copepod *Tortanus dextrilobatus*, now broadly distributed in San Francisco Bay, at times reaching extremely high abundances (>103/m^3), which is especially noteworthy for a carnivore. This large, predatory copepod seems to select larger, native copepods (*Acartiura* sp.) over smaller, non-native copepods (e.g. *Oithona davisae*). *Tortanus dextrilobatus* is one of several non-native copepods that have resulted in a dramatic change in the composition of the zooplankton community in San Francisco Bay over the last 20 years, which raises the question of whether successfully established NIS may facilitate invasions by future NIS (Bollens et al. 2002). Predatory impact of *T. dextrilobatus* in the San Francisco Estuary was estimated (% population consumed/d). Greater than 1% occurred on a regular basis when *T. dextrilobatus* was abundant, with maxima exceeding 20, 65, and 25% for *O. davisae*, *Acartia* (*Acartiura*) sp. and all Copepoda, respectively (Hooff and Bollens 2004).

In October 2003 New Zealand mudsnails (*Potamopyrgus antipodarum*; NZMS) were discovered in Putah Creek and since have been found in Calaveras River, Napa River, Mokelumne River, American River, and in small creeks throughout Southern California. NZMS is a very small snail with the potential of extraordinary population densities of up to approximately a million snails per square meter. To date, there has been little research on the potential impacts of New Zealand mudsnails on other aquatic resources. The CDFG has created education and outreach materials to increase awareness by anglers and others in contact NZMS infested waters. These snails can survive out of water on wading and fishing gear for extended periods (up to 25 days if they are in a moist environment). Also in 2007, ANSTF produced a National Management and Control Plan for the New Zealand Mudsnail (ANSTF 2007).

The USFWS Delta Juvenile Fish Monitoring Program (DJFMP) has conducted beach seining to monitor long term trends in juvenile fish abundance in the Sacramento-San Joaquin River Delta. Hanni and Chapman (2006) found that the number of non-native species is increasing through time while the number of native species is declining, suggesting that non-natives are out-competing natives for common resources in the Delta.

Interagency Ecological Program for the San Francisco Estuary (IEP) monitoring data from 2006 showed that the introduced copepod *Limnoithona tetraspina* abundance increased while another introduced copepod *L. sinensis* continued to be collected in very low numbers in 2006. The introduced freshwater calanoid copepod *Pseudodiaptomus forbesi* has remained relatively abundant in spring and summer compared to other copepods. *Acanthomysis bowmani* is an introduced mysid has been the most abundant mysid in the upper estuary since fall 1993, after reaching a low in 2005, spring abundance continued to decline in 2006 to less than half of the average annual spring abundance. *Neomysis kadiakensis* has never become common and some of the upper-estuary specimens may be a second species, *N. japonica* (Hennessy and Hieb 2007). *Palaemon macrodactylus*, the oriental shrimp, remained a minor component of the total shrimp catch. *Exopalaemon modestus*, the Siberian prawn, first collected in the lower Sacramento River in 2000, was the most common caridean shrimp in the lower Sacramento and San Joaquin rivers as of 2002, outnumbering both the native *Crangon franciscorum* and the introduced *Palaemon macrodactylus* in these areas (Hieb 2007a). A similar trend was reported for Suisun Marsh (Schroeter et al. 2006). *Exopalaemon modestus* catch peaked from October to December in the Bay Study trawls and in September and October in the Suisun Marsh trawls. Their primary reproductive areas are in freshwater upstream areas of Suisun Marsh (Hieb 2007a).

The distribution, population dynamics, and life history attributes of the Chinese mitten crab (*Eriocheir sinensis*) in the San Francisco Bay and its tributaries was documented.

In the winter of 2006-07, Bay and Suisun Marsh surveys did not detect any Chinese mitten crabs and only 12 were salvaged at the CVP/SWP fish facilities, the lowest total since *E. sinensis* was first detected at the CVP fish salvage facility in fall 1996. USFWS monitoring for juvenile *E. sinensis* in the delta and its tributaries again detected no crabs in 2006, and there were also no public reports of *E. sinensis*. Although the factors that control the estuary's *E. sinensis* population are not well understood, winter temperatures and outflow are hypothesized to affect larval survival and settlement time. A "boom-and-bust" cycle has been reported for some introduced species, although this may not be universally true for all introductions (Hieb 2007b).

IEP also provides in their newsletter and reports status information on various additional species including many which are introduced (including American shad (*Alosa sapidissima*),Threadfin shad (*Dorosoma petenense*), Striped bass (*Morone saxatilis*), and the shokihaze goby (*Tridentiger barbatus*) (Greiner et al. 2007).

Moyle and Marchetti (2006) found no set of characters that predicted success for all fish invasions, although some characters increase the probability of success. The factors that best predict invasion success are a) a history of successful establishment outside the species' native range; b) characters that promote success at multiple stages of the invasion process (e.g. high physiological tolerance); c) invaded habitat that more or less matches the alien's native habitat; d) high fish species richness, including other alien fishes; and e) propagule size exceeding 100 individuals.

According to Lund et al. (2007) the key to restoring desirable pelagic species is to recreate habitats that have a high variability in abiotic factors such as salinity, channel flows, depth, and water clarity (Nobriga et al. 2005, Lopez et al. 2006). This is the kind of estuarine habitat that once dominated many Delta channels and Suisun Bay: open-water areas that varied sufficiently in salinity from fresh to moderately salty seasonally, or across years, and often had strong tidal currents and low water clarity (Lund et al. 2007). In areas where such conditions return, it is unlikely that the overbite clam, Brazilian waterweed, or the Asiatic clam will be able to persist (Lund et al. 2007). The overbite clam is highly stressed when exposed to fresh water (Werner 2004) and has not colonized areas in the estuary that are fresh for extended periods of time, despite being physically able to do so (Lund et al. 2007). This suggests that annual exposure to fresh water for three to six months may limit its ability to invade some areas (Lund et al. 2007).

A great amount of progress has been made toward the five Stage 1 Expectations: 1) Ballast Impacts monitoring, management, and treatment, 2) outreach regarding live bait industry, 3) public information programs regarding species introductions, 4) assessment of the pathways, risks to reduce, and eventually eliminate, introduction of unwanted aquatic organisms from these sources into natural waters, 5) assessment of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts.

Despite these efforts the problem is getting worse. Lund et al. (2007) points out that the old paradigm was “alien (non-native) species are a minor problem or provide more benefits than problems,” and that the new paradigm is that “alien species are a major and growing problem that significantly inhibits our ability to manage in support of desirable species.” ERP, the implementing agencies, other Federal, State, and Local Agencies, and the private sector need to do more to face the threat that invasive species pose.

Currently there is no way to assess trends in invasions, rates of invasions or whether populations are increasing or declining. Conducting a sampling program similar to the current survey on a regular interval (possibly every 3-5 years), using standardized methods, would offer the opportunity to observe the changes in the communities sampled over time (Maloney et al. 2007). Also, it would be worthwhile for future Delta surveys to incorporate into the sampling protocol a method of collecting measurements of physical environmental conditions from each sample site, including but not limited to salinity and water temperature. Using that information, researchers would be able to look for correlations between the habitats of the Delta, the large variety of environmental conditions available across the Delta, and the distribution of species collected and identified in the surveys (Maloney et al. 2007).

The Pelagic Fish Action Plan suggested the following next steps to address invasive aquatic species:

- Support CSLC’s work to control ballast water by assisting with studies related to the Estuary. CDFG is charged with oversight of studies to determine the location and geographic range of NIS in CA estuaries and coastal areas, and to assess the effectiveness of ballast water controls.
- Assist CSLC, CDFG, and other agencies with the development of regulations or control measures for hull-fouling.
- Support the implementation of the California Aquatic Invasive Species (AIS) Management Plan.

Finally, the higher-cost of control and eradication programs will not be needed if species that are potentially invasive are kept out of the state. To prevent more aquatic invasive species from entering the state, agricultural inspection stations should be operated on a 24/7 basis and inspect all boats and watercraft entering the state. ERP needs to complete an assessment of existing introductions to identify those with the greatest potential for containment or eradication, and consider this in prioritizing control efforts. ERP needs to establish a program to monitor for new invasions of non-native wildlife, and respond quickly to contain and eradicate them.

<u>Potential Future Activities in the Delta and Suisun Planning Areas</u>

- Continue implementing the CALFED NIS Strategic Plan, to prevent new introductions; limit spread or eliminate NIS populations through management; and reduce ecological, economic, social, and public health impacts of NIS infestation. Funding in the amount of $100,000 to DFG and $196,725 to USFWS to continue coordination activities, and to hold training workshops on the HACCP program developed by UC Extension Sea Grant.

- Continued mapping of Egeria through funding to DBW's existing Egeria Densa Control Program *[need cost estimates]*
- Continued research and monitoring to increase our understanding of the invasion process and the role of established NIS in ecosystems in the Delta and Suisun. Specifically:
- Does Egeria or Microcystis invade newly restored sites? Conduct site-specific surveys to verify whether these NIS are present and spreading, and conduct water quality monitoring for parameters that could contribute to invasion by NIS (e.g. DO, temperature, salinity).
- What is the potential role of alien jellies in relation to pelagic and planktonic fish? Are they increasing in abundance due to decline in other pelagic predators and greater prey availability, or are there other things going on?
- There is a hypothesis that recreating habitats that have a high variability in abiotic factors (e.g. salinity, channels flows, depth, water clarity) make it unlikely that overbite and Asian clams, and Egeria, would be able to persist (e.g. annual exposure to freshwater for 3-6 months may limit Corbula's ability to invade areas). Continued study on effectiveness of localized treatment of zebra and quagga mussels using soil bacteriu*m.*

2. NATURAL FLOW REGIMES

One extensive study, Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River (ERP-02D-P61), seeks to quantify key aspects of a "naturalized" flow regime of the Sacramento River that is compatible with flood damage reduction, agriculture, diversions, storage and conveyance. Stillwater Sciences (2007) infer that the cumulative deficit of coarse sediment since dam construction (i.e. past > 60 years) has been on the order of 3 million yd^3 for the reaches downstream of Shasta Dam. The deficit of coarse sediment from the upper watersheds was exacerbated by the nearly 7 million yd^3 of sediment that was mined from the river and floodplains for dam building, and the 1.8 million yd^3 of aggregate that was mined to support urbanization of Redding (Stillwater Sciences 2007). As part of the ongoing gravel study, Stillwater Sciences is using a new sediment transport model to predict bedload transport rates under the current hydrology. In this way, the model will provide a much more reliable estimate of the overall post-dam coarse sediment deficit, and will also help us understand how it affects the extent and quantity of gravel in storage on the river bed.

<u>Potential Future Activities in the Delta and Suisun Planning Areas</u>

- Extension of TNC's Ecological Flows Tool (developed for the Sacramento River) to the Delta
- "Variable Delta" hypothesis on localized scale – (ties in with non-natives): see if manipulation of DO, salinity, flows, and temps can help control SAV on localized scale, as well as how species use or avoid these conditions.

- As part of a comprehensive monitoring program for the Delta, improve monitoring of in-Delta hydrodynamics and fish assemblage response to generate accurate numerical models.

3. Channel Dynamics, Sediment Transport and Riparian Vegetation

Rivers are naturally dynamic. They migrate across valley floors as flows erode banks and deposit sediment on point bars; they occupy different channel alignments through channel avulsion; they periodically inundate floodplains; they recruit and transport sediment; and they drive the establishment and succession of diverse riparian plant communities. These physical processes provide the energy and material necessary to create and maintain healthy and diverse riverine habitats that support native populations of plants, fish, and wildlife. We generally do not know the scale and balance of inputs--flow, sediment, organic material--and channel modifications that will restore riverine ecosystem function. Nor do we know how channels and habitats downstream of dams have adjusted to the post-dam flow regime and how, therefore, the re-invigoration of dynamic riverine processes will affect overall habitat (CALFED Bay-Delta Program. 2000).

The following is a brief description of activities that have been implemented during CALFED Stage 1. A more complete description of these activities and more can be found in the ERP End of Stage 1 Report.

Delivery of suspended-sediment from the Sacramento River to San Francisco Bay has decreased by about one-half during the period 1957 to 2001 (Wright and Schoellhamer 2004). Three large reservoirs in the watershed have accumulated a mass of sediment of the same order of magnitude as the decrease in suspended-sediment yield over the time period of study. Along with reservoir sedimentation, bank protection measures and the gradual depletion of stored hydraulic mining derived sediments have the potential to decrease sediment yield. This finding has implications for planned tidal wetland restoration activities around San Francisco Bay, as an adequate sediment supply will be needed to build subsided areas to elevations typical of tidal wetlands as well as to keep pace with projected sea-level rise. In a broader context, the study underscores the need to address anthropogenic impacts on watershed sediment yield when considering actions such as restoration within downstream depositional areas.

In the Sacramento–San Joaquin River Delta, USGS found during the period from 1999-2002 6.6 million metric tons of sediment entered the Delta and 2.2 million metric tons exited the Delta, resulting in 4.4 million metric tons of deposition (Wright and Schoellhamer 2006). This mass of deposited sediment corresponds to approximately 2 cm of deposition averaged over the entire open-water and wetland area from 1999-2002 (or 0.5 cm/yr) (Wright and Schoellhamer 2006). Eighty-five percent of the suspended-sediment came from the Sacramento River, 13% came from the San Joaquin River, and 2% came from other sources (Wright and Schoellhamer 2006). The wet season lasted about 4 months per year but accounted for 82% of the sediment supply and 85% of the total deposition (Wright and Schoellhamer 2006).

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

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

The CALFED Science program funded research that measured meander migration rates in the Sacramento River between Red Bluff and Colusa Constantine et al. (2006). Results show two temporally persistent patterns in migration rates: a previously recognized downstream alternation of active and stable reaches, and a mid-basin peak in migration rates. Stable reaches form where the river contacts resistant bank material, and these reaches follow a distinctive temporal evolution. Among active reaches, migration rates increase through a zone of declining bed shear stress and stream power and peak where sinuosity and bankfull discharge are greatest (Constantine et al. 2006). Bankfull discharge and migration rates decline where frequent overbank flooding occurs. Increasing interaction of the channel with levees may contribute to the decline of migration rates (Constantine et al. 2006). These results suggest that both point bar growth, and curvature, drive migration in active portions of the river and that discharge plays a role in controlling migration rates by limiting the river's ability to erode and transport bank material (Constantine et al. 2006).

Merced River Corridor Restoration Plan Phase IV: Dredger Tailings Reach project collected baseline scientific data on the Merced River Dredger Tailings Reach. Results indicate that 1) the contemporary floodplain is largely inaccessible to flood flows; 2) the channel sediment is frequently too coarse for spawning habitat; 3) very little sediment transport occurs other than re-distribution of gravels at augmentation sites; 4) the coarse floodplain sediment has little stratigraphic differentiation above the water table; and 5) levels of mercury are mostly very low (Downs and Diggory 2006).

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

USGS studied the channel response to the Saeltzer Dam removal on Clear Creek (Miller and Kondolf 2006). The dam removal has allowed over 3000 m^3 of sediment to erode from the former dam site. About 10% of the total volume has redeposited in a downstream riffle. High flows caused lateral bank erosion to occur which led to the desiccation and mortality of riparian trees near the site.

DWR funded restoration of 238 acres of former agricultural fields along the Lower Tuolumne River was initiated by notching surrounding berms to restore hydrologic connectivity, and planting 60 acres with native riparian trees and shrubs (Hayden et al. 2007). Results imply that restoration of floodplain hydrogeomorphic function at this site is modest under regulated flow conditions without lowering floodplain surfaces. However, it does provide periodic benefits to aquatic ecosystems during wet years and will continue to improve riparian conditions for terrestrial species as planted and naturally recruited vegetation matures (Hayden et al. 2007).

Establishing riparian vegetation is an important part of restoring riparian habitat. The following findings and recommendations were provided by the "Sacramento River Ecological Flows Study: State of the System Report" (Stillwater Sciences 2006):

- On the Sacramento River, successful cottonwood recruitment occurs at relative elevations of 3–9 ft above summer baseflow levels (Roberts et al. 2002, TNC 2003). Similar results have been observed along the lower Tuolumne and San Joaquin rivers, although the successful recruitment band in these smaller rivers tends to be at slightly lower elevations of 2–6 ft (McBain and Trush 2002, Stillwater Sciences 2003 and 2006a, Stella 2005).

- Field studies on Sacramento River point bars (TNC 2003a, Morgan 2005, Morgan and Henderson 2005a and 2005b) indicate that successful establishment of large cohorts of Fremont cottonwood seedlings are most likely to occur when water table/river stage declines at average rates of less than 0.8 in/day (Stillwater Sciences 2006a, Stella 2005, Morgan 2005, Morgan and Henderson 2005b). These studies also indicate that rates of decline in the range of 0.8 to 1.6 in/day are stressful to seedlings, but may still support survival of a smaller cohort of seedlings. It is also possible that steeper rates of river stage recession may be acceptable if they are offset by periods of 1 or more days of stable water levels, which would produce a stepped recession limb of the recruitment flow hydrograph (TNC 2003, Stillwater Sciences 2006a).

- Reductions in the magnitude and frequency of winter overbank flows in the post-dam era have presumably led to an overall decrease in soil moisture during the growing season for cottonwoods and other riparian plants. It has been hypothesized that this contributes to reduced growth rates and alters competitive interactions so that species more tolerant of drier conditions may become more dominant (Roberts et al. 2002, Stillwater Sciences 2006, Stella et al. 2006), resulting in more abundant box elder and walnut (Wood 2003, Vaghti 2003, Fremier 2003).

- The lower magnitude, and possibly altered timing, of spring flows may have affected cottonwoods by encouraging recruitment on low depositional surfaces that become inundated by subsequent winter floods or by elevated summer baseflows (Morgan 2005, Morgan and Henderson 2005a & 2005b, Stillwater Sciences 2006).

- Morgan (2005) concluded that there were three primary attributes of the current altered hydrograph that limit cottonwood seedling survival at the middle Sacramento River study sites: 1) the reversal of summer flows such that there is now a trend of increasing summer flow levels during cottonwood seed release and seed germination periods, 2) rapid stage declines during the spring pulse flow such that root growth in seedlings established during the typical recruitment period cannot keep up with declining water levels, and 3) the immediate drop in stage late in the growing season when reservoir releases for summer irrigation cease.

- To promote riparian vegetation recruitment and establishment in the Sacramento River corridor, the State of the System report (Stillwater Sciences 2006) recommended that agencies:

  1. Manage the recession limb of spring high flow events in wet water years to promote seedling establishment of cottonwoods and willows.
  2. Promote channel migration to create new seedbeds for cottonwood recruitment through scour and fine sediment deposition.
  3. Promote strategic horticultural restoration on higher floodplains surfaces where passive recruitment is infeasible.
  4. Prioritize actions to eradicate and control invasive plant species.

A predictive model for recruitment of cottonwoods and willows on the Lower San Joaquin Basin has been developed by Stillwater Sciences (2006a). Physical and biological mechanisms affecting establishment of riparian vegetation were identified in order to identify the most cost-effective strategies and sites for riparian protection and restoration.

Indexing flow planning for water year type is an important tool to use to promote the recruitment of riparian vegetation. Using the California Department of Water Resources (CDWR) water year classification for the San Joaquin and Sacramento rivers, a dual approach to flow management for riparian vegetation issues was recommended: 1) for wet and above-normal years, a focus on seedling recruitment; and 2) in all other years, a focus on survival of seedlings recruited in previous years by sustaining groundwater levels in summer (Stillwater Sciences 2006a).

River Partners studied the issue of flood conveyance verses revegetation. Using two-dimensional hydraulic modeling as a planning tool, they showed that flood-neutral riparian revegetation can be designed within a floodway with careful planning for the hydraulic effects of flood flows (Griggs 2007).

Protecting riparian vegetation is one of the purposes of biotechnical bank protection. Brush boxes were a biotechnical bank protection measure utilized to restore habitat in the Sacramento-San Joaquin Delta. Brush boxes were found to decrease erosional processes and favor depositional processes. They also maintained planted species and recruited others. According to Hart and Hunter (2004), the most promising use of these biotechnical structures is in those situations where a calming period is required to establish plants, after which they would be self-sustaining.

Holl and Crone (2004) sampled naturally colonizing riparian forest understorey plant communities in 15 riparian forests restored by planting native woody species along a 150-km stretch of the Sacramento River. They found cover and species richness of exotic understorey plants decreased strongly with increasing overstorey cover, and were lower in quadrats closer to river base flow.

Wood and Little (2007) compared plant community composition and structure in established restoration along the Sacramento River. The restoration plots compared favorably to remnant plots. Remnant plots had slightly lower mean species richness, slightly higher mean percent native species, and significantly higher mean stem basal area (Wood and Little 2007). As would be expected, remnant plots were found to have large trees and occur in frequently flooded areas, whereas restoration plots tended to have multi-stemmed shrubs, small trees, and occur in both low-lying and higher terrace locations. These findings indicated that restoration revegetation should reach the intended condition once the trees reach full size, and if exotic species are controlled.

Riparian restoration projects were also found to restore non-target species. Williams (2007) investigated bee and flowering plant communities at restored sites and riparian remnants. Average richness and abundance did not differ between sites types, indicating that restored habitats supported abundant and diverse pollinator communities within five to ten years after planting. A study compared of surface-active beetle assemblages in remnant and restored riparian forests of varying ages. Analyses indicated that as restoration sites age, their assemblages increasingly resembled those found in remnant riparian forests (Hunt 2007). Small (2007) found no difference in nest predation rates on restoration and mature remnant forest sites. Small (2007) also found that flood timing influences nest predation rates for Black-headed Grosbeaks (*Pheucticus melanocephalus*), possibly by driving mammalian nest predator population cycles. Golet et al. (2007) studied small mammal distribution and abundance at four habitat types (agricultural, young restoration, older restoration, and remnant riparian). They found that although certain orchard pests (especially voles) had relatively high abundances at young restoration sites, these declined as sites matured. Overall, relative abundance of small mammal pests was typically lower in older restoration sites and remnant habitats than in agricultural sites. A conservation concern was the high relative abundance of exotic black rats (*Rattus rattus*), a predator of songbird nests and roosting bats, in older restoration sites and remnant riparian forests (Golet et al. 2007).

Climate change will have a potentially large, but yet unknown, effect on sediment availability in the future. Sea level rise has accelerated and the landward movement of the marshes has been restricted by the bay and marsh front levees. The marshes have been 'squeezed' between the rising water and the levees, resulting in erosion of the mudflats and loss of marsh. In turn, the loss of marsh in front of the levees has allowed larger waves to reach and erode the levees. Most restoration projects in San Francisco Bay are subsided sites separated from the Bay or slough by levees. With each passing year, subsided land in the Bay and Delta will require additional material to be restored.

<u>Potential Future Activities in Delta and Suisun Planning Areas:</u>

- Research to determine scale and balance of flow, sediment, and organic material inputs needed to restore riverine ecosystem function.
- Determine how downstream channels and habitats have adjusted to post-dam flow regimes and how re-invigoration of riverine processes upstream will affect this habitat.

4. & 5. Flood Management as an Ecosystem Tool and Bypasses

Floodplains have the potential to support highly productive habitats with a direct linkage to aquatic species. Restoration opportunities exist for riparian and riverine aquatic, fresh emergent wetland, seasonal wetland, non-tidal and tidal perennial aquatic, and perennial grassland habitats. Floodplains should represent a heterogeneous mosaic of these vegetation types. There has been extensive research on the Yolo Bypass and Cosumnes River indicating that native resident and migratory fish show a positive physiological response when they have access to floodplain habitats (Ribeiro et al. 2004). Floodplains support high levels of primary and secondary productivity by increasing residence time and nutrient inputs into the Delta (Sommer et al. 2004) and provide important spawning and rearing habitat for splittail and rearing habitat for

Chinook salmon (Sommer et al. 2001, Sommer et al. 2002, Moyle et al. 2007). Managing the frequency and duration of floodplain inundation during the winter and early spring, followed by complete drainage by the end of the flooding season, could favor native fish over non-natives (Moyle et al. 2007, Grimaldo et al. 2004). Splittail are obligate floodplain spawners (Moyle et al. 2004). Without access to adequate floodplain spawning habitat splittail populations decline drastically as seen during the 1990's. Numerous native fish use floodplains in their life cycles for spawning and growth (Moyle 2002). While stranding can be a problem on floodplains it only occurs in man-made locations such as artificial ponds or barriers like the Fremont Weir (Moyle et al. 2007). Floodplain restoration must incorporate as much natural connection with the river as possible to reduce the stranding of native fish. Floodplains have great value to native fish assemblage restoration in California. Many native fish have evolved to take advantage of seasonally inundated floodplains in the winter and spring, while most non-native fish use floodplains in their native ranges in summer. When floodplains in California dry out in late spring and early summer non-native fish are precluded from using them as spawning and rearing areas. This type of habitat gives native fish a competitive advantage over non-native fish, which has been implicated in the decline of native fish throughout the State.

Duration and timing of inundation are important factors that influence ecological benefits of floodplains. PWA and Opperman (2006) have defined a Floodplain Activation Flow (FAF) for floodplains on the Sacramento River. For floodplains on the Sacramento River an inundation regime that allows for desired ecological outcomes would consist of:

1. Timing: period of March 15 to May 15
2. Duration: active flooding persists for a minimum of seven days (though the floodplain inundation is likely to persist considerably longer)
3. Frequency: an exceedence frequency of 67 percent or two out of every three years. (PWA and Opperman 2006)

Floodplain Activation Flows are very important, as are periodic large volume flows. Large scale events are more effective at reworking the floodplain landscape in a natural way. Evidence on the Cosumnes River indicates that dynamic processes are needed to support complex riparian habitats and upland systems which form the floodplain mosaic habitat (Moyle et al. 2007). Native plants and animals have adapted to these stochastic events that are characteristic of California's hydrology. These stochastic events help to control non-native plants and animals. Large scale events reduce stranding by creating channels on the landscape which allow for natural drainage.

Yolo Bypass has shown the greatest promise for large scale (8,500+ acres) ecological benefits at modest flow rates (2,000 cfs) (PWA and Opperman 2006). This timing and rate of inundation are seen as minimum values for ecological benefits. As the flow rate increases the ecological benefits increase as well. In order for this to be achieved on the Yolo bypass a notch in the Fremont wier with an operable gate and fish passage facilities would need to be constructed. PWA and Opperman (2006) have outlined a methodology for use with other floodplains which can be applied to the San Joaquin River and the lower Mokelumne River. Floodplain expansion will also help alleviate flooding potential. New, alternative levee designs (setback levees) could provide localized, smaller scale floodplain habitat in the existing channels of the Delta. For example, anticipatory erosion control designs that treat levee damage/failure mechanisms and integrate river bank reconstruction with riparian restoration can create functional habitats for fish.

The Cosumnes River is the only remaining unregulated river on the western slope of the Sierra Nevada. The Cosumnes River Preserve comprises 46,000 acres and includes all associated Central Valley habitats and their dependent wildlife. The free-flowing nature of the river allows frequent and regular winter and spring overbank flooding that fosters the growth of native vegetation and the wildlife dependent on those habitats. Research on floodplain benefits from the Cosumnes River show the many benefits this type of landscape can have. Ahearn et al.(2006) has shown that flood plain that is wetted and dried in pulses can act as a productivity pump for the lower estuary. With this type of management the floodplain exports large amounts of Chlorophyll *a* to the River (Ahearn 2006). Native fish have shown many benefits from this type of habitat on the Cosumnes preserve as noted above (Moyle et al 2007, Swenson et al. 2003, Ribeiro et al. 2004, Grosholz and Gallo 2006).

The Department of Water Resources' Flood Protection Corridor Program grants funds for the acquisition of flowage easements; such funding could provide an additional tool to yield floodplain benefits to species seasonally, while accommodating production agriculture in summer, fall, and early winter. The strategy assumes that new floodplains would be shaped and developed based upon availability of flows or changes in river or export operations that might influence/contribute to restoration. In those areas where old flood structures such as Paradise Cut along the San Joaquin River exist, restoration and enhancement opportunities should take into consideration the flow and duration needs of species. It is fair to recognize that a new paradigm is needed for how floodplain and, more importantly, flood control is considered. The historic view has been to construct and design channels that transport water quickly away (reducing residence time) rather than providing overflow areas where flows can spread out over terrestrial dominated landscapes (increasing residence time). The energy and forces from the seasonal events are critical processes that shape sediment accretion, suspension, and ultimately floodplain habitats.

In the Sutter Bypass, construction has been completed on a new East-West Weir to provide fish passage and improved control of the water diversion in the East and West channels in the Sutter Bypass. In addition, Weir No. 5 has been rehabilitated to control the water level in the West Side Channel and regulate the downstream. Real-time flow monitoring projects in the lower Sutter Bypass, past and ongoing, provide data on minimum instream flows and water quality required for the recovery of at-risk fish species. These projects contribute valuable monitoring data to the vision for the Sutter Bypass which will provide a healthy streamflow pattern in the bypass and emulate the natural runoff pattern, with a late-winter/early-spring flow event and summer-fall base flows that maintain important ecological processes, functions, habitats, and important species

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There are approximately 77 projects that have provided either planning or acquisition of property for restoration of floodplain in various locations throughout the CALFED Regions. One project that needs to move forward is the Yolo Bypass Management Strategy Project which provides guidance for the 59,000 acre Yolo Bypass. The purpose of the project is to foster stakeholder stewardship in order to encourage practices that protect and enhance fish and wildlife habitat, while respecting and maintaining economic viability of the land and water users, and maintaining flood management functions. Another project which will help ERP reach its goals to restore floodplain is the Restoring Ecosystem Integrity in the Northwest Delta project. It is developing plans for fee acquisition or conservation easement acquisition within the Jepson Prairie-Prospect Island Corridor. Planning for various sub-reaches of the Sacramento River have been or are nearly complete (e.g. Colusa Subreach Planning on the Sacramento River between River Miles 143.5 and 164.5). Implementation of these plans should be start soon. The BDCP has identified various places in the Delta that are suitable elevationally as floodplain/bypass habitat. The San Joaquin River upstream of Mossdale Crossing shows promise for a set back levee floodplain. The San Joaquin River has very little remaining natural habitat and this floodplain will provide valuable habitat for native fish. The Stone Lakes bypass, however, has dubious positive ecosystem impacts. Water put into the Stone Lakes bypass would originate in the Sacramento River and exit the floodplain into the Mokelumne River system. This has the opportunity to provided false attraction and straying of adult Sacramento system salmon into the Mokelumne River. In addition, Stone Lakes has several large permanent bodies of water that contain dense growth of SAV. As stated earlier one of the major benefits of floodplain is its ability to completely dry in summer. These large lakes will not dry out and may become excellent habitat for non-native predatory fish which could offset the perceived benefits.

Natural floodplains should be identified that can be inundated with minimal disruption of human activity. Where positive benefits are shown, flow recommendations have been developed and instituted when feasible:

- Focused Action to Develop Ecologically-based Hydrologic Models and Water Management Strategies in the San Joaquin Basin (ERP-00-B04)
- A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin (ERP-00-F04)
- Lower Deer Creek Restoration and Flood Management: Feasibility Study and Conceptual Design (ERP-02D-P53)
- Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River (ERP-02D-P61)

See Riparian and Riverine Aquatic Habitats Eco-element for A Mechanistic Approach to Riparian Restoration in the San Joaquin Basin (ERP-00-F04) and Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River (ERP-02D-P61).

Strategies for the restoration of natural channel and floodplain dynamics (e.g. East Delta Corridor Habitat Studies: Cosumnes and Mokelumne Rivers Feasibility Study (ERP-99-C01/C02), Physical Modeling Experiments to Guide River Restoration Projects (ERP-02D-P55), and Implementing a Collaborative Approach to Quantifying Ecosystem Flow Regime Needs for the Sacramento River (ERP-02D-P61) and implementation of a large demonstration project (The Influence of Flood Regimes, Vegetative and Geomorphic Structures on the Links between Aquatic & Terrestrial Systems (ERP-01-N01) have been developed.

The Sacramento River Riparian Mapping Project (ERP-96-m16) developed inventories and maps of riparian lands along the Sacramento River and its major tributaries. The study area was confined to streams in the Sacramento Valley, and mapping ended in the foothill canyons on both sides of the Valley. The project was done in four phases: Phase 1 included southern Shasta County, Phase 2 included Tehama County, Phase 3 included Butte County, and Phase 4 included the Sacramento River mainstem to Suisun Bay, the Feather, American, Yuba, and Bear Rivers, Butte Sink, the Sutter Bypass, and Stony, Cache, and Putah Creeks on the west side.

In support of Stage 1, Digital Soil Survey Mapping and Digital Orthophotoquad Imagery Development (ERP-01-n30) produced two digital data layers for 9 Soil Survey Areas. These two layers are a Digital Orthophotoquad (DOQ) layer and a certified electronic digital soils data layer with accompanying soil property and interpretations attribute tables. The nine study areas are located in the Shasta Area, Glenn County, Nevada County, the Amador Area, the Eastern Stanislaus Area, the Merced Area, the Madera Area, Tehama County, and Sonoma County.

Another project, Geomorphic and Geologic Mapping for Restoration Planning (ERP-02-p45), mapped geomorphic landforms and geologic deposits along the lower Sacramento, San Joaquin, and Cosumnes rivers for input into ecosystem restoration planning and levee engineering. The maps show: 1) the distribution of historical river landforms (including natural levees, floodplains, and stream channels) for floodplain and habitat restoration; 2) likely locations of historic hydraulic mining-derived sediments stored along the river margins; and 3) the likely composition of foundation materials underlying existing levees for evaluation of levee stability.

The Lower Deer Creek Restoration and Flood Management: Feasibility Study and Conceptual Design project (ERP-02D-P53) created a three-dimensional hydrodynamic model to simulate a large flood event that resulted in levee failure. Simulation results provide detailed information about the capacity of floodplain pathways and will be used to help guide the planning and implementation of future flood management strategies on Lower Deer Creek.

Geomorphic and Geologic Mapping for Restoration Planning, Sacramento-San Joaquin Delta Region (ERP-02-P45) mapped geomorphic landforms and geologic deposits along the lower Sacramento, San Joaquin, and Cosumnes rivers for input into ecosystem restoration planning and levee engineering. This research provides a record of long-term changes along the lower Sacramento River that have shaped current conditions. Maps cover nine USGS quadrangles from Courtland to Rio Vista, and identify geomorphic landforms along the river and associated sediments, including older, denser sediments that are stable foundations for set back levees. The mapping shows the distribution of remnant sediments from historic hydraulic mining that washed downstream into river floodplains during the 19th century. These historic sediments, with potentially high mercury contents, currently are stored along the margins of, and within historic floodplains of, the Sacramento River and are separated from the current river system by the modern levee system.

Finally, the very high risk of urbanization within or adjacent to the Delta continues to be a major impediment to floodplain restoration in and around the Delta. No one project identified all existing unurbanized floodplains in the Central Valley or prioritized floodplain restoration projects; however there are several projects that contributed to this action:

- Merced River Corridor Restoration Plan - Phase II (ERP-98-E09 Merced)
- Sacramento River Conservation Area Program (ERP-01-N28 Sacramento)
- Restoring Ecosystem Integrity in the Northwest Delta: PHASE II (ERP-02-P21 Cache Slough)
- Sub-Reach Planning for the Sacramento River: River Mile 144-164 (ERP-02-P27 Sacramento)
- Geomorphic and Geologic Mapping for Restoration Planning (ERP-02-P45 Delta)

The cost to restore flooded and subsided Delta islands varies widely with the approach taken. Some of the planned restorations encompass a wide range of current conditions and future trajectories. None of the study results or interpretive reports from the body of work funded by ERP during Stage 1 challenged the concept that the least subsided, least costly and least risky (in terms of threats to infrastructure and property) restoration projects will be the easiest to implement. Other considerations, such as the impacts of a proposed isolated facility will have to be addressed in future planning, resource management and funding efforts.

<u>Potential Future Activities in the Delta and Suisun Planning Areas</u>

- Continue activities occurring in the Aquatic Restoration Planning and Implementation Section of DWR – development of habitat enhancement and fish passage improvement in the Yolo Bypass. Continued coordination with Yolo Basin Foundation and other local groups to identify, study, and implement projects on public or private land with willing participants, to create regionally significant improvements in riparian, tidal marsh, and seasonal floodplain habitats and fish passage in the bypass. Estimated cost of $1 million to continue these efforts.
- Continue working with the participants in the Yolo Bypass Strategic Plan process to ensure the project scope includes coordination and collaboration necessary to take advantage of previous and current investments in the Lower Bypass in order to ensure the most current available information is being used in the discussions. Estimated cost of $300,000 to continue these efforts.

- Continue implementing projects at Cosumnes River Preserve – use engineered levee breaches and grading to restore an active and regular flooding regime; restore flooded riparian forest habitat; measure wildlife and plant community response to restoration treatments; monitor changes in surface and ground water hydrology; and monitor geomorphic changes occurring throughout the restored site using remote sensing techniques.
- BREACH III/COYOTE project: Continue lower Yolo Bypass technical site evaluation, monitoring, research, and feasibility assessment to greatly improve our understanding of aquatic species' response to tidal wetland restoration. BREACH III component will undertake physical and geomorphic process evaluation, and COYOTE portion will monitor connectivity and key ecological variables (comparing Yolo Bypass and Cosumnes River systems) to assess project performance and the impacts of seasonal and interannual hydrologic variability. Results should be a comprehensive monitoring and research approach that should greatly improve ability to make sound decisions re future management, restoration potential, and flood control needs in the lower Bypass.

6. SHALLOW WATER TIDAL AND FRESHWATER MARSH HABITAT

The ERP Strategic Plan states that "…the ERP will restore wetland habitats throughout the Bay-Delta ecosystem as part of an ecosystem-based management approach". It was assumed that loss of tidal wetland habitats was a contributing factor in the decline of species of concern, and that restoration of these habitats would contribute to the recovery to sustainable populations. It was acknowledged in the ERP Strategic Plan that causal links between tidal marsh habitat and species' population abundance had not been established, and that restoration should be designed as large-scale experiments for determining the relationship between habitat characteristics and population health. A major concern at the time was that restored habitat would be colonized by non-native species, which in turn would limit the benefits to native species.

Four general categories of information needs were identified in the ERP Strategic Plan:

- <u>Species needs</u> relative to inundation and salinity regimes in tidal wetlands (both native and non-native species).
- <u>Growth and reproduction</u> of selected species and their linkage to inundation and salinity regimes.
- Identification of <u>limiting factors</u> which determine distribution and abundance of selected species.
- Evaluation of habitat spatial characteristics (e.g. size, shape, connectivity) for effect on population dynamics of selected species. This could be achieved through observation at existing habitats, where available, or by creating a diversity of tidal marsh habitats.

<u>Freshwater Tidal Marsh</u>

The only significant increase in freshwater tidal marsh in the Delta since the completion of the ERP Strategic Plan has been on Liberty Island. This was not a planned restoration project but a levee failure that resulted in the inundation of most of the 5209 acre island. About 800 acres of this island has passively restored to emergent tidal marsh. Liberty Island was acquired post-levee breach using ERP funds. The planned Dutch Slough Restoration Project would restore up to 483 acres of emergent wetland (a portion of which would be tidal) in the Delta. The plan would restore habitat and generate information on how to best restore tidal marsh habitat in the Delta. Many more large-scale projects will need to be undertaken in order to meet the information needs for freshwater tidal marsh in the Delta. Project planning and/or acquisition of conservation easements have been initiated for a few additional sites.

Studies of tidal marsh habitat in the Delta are limited. The largest effort at studying tidal marsh habitat and benefit to native species are the ERP funded BREACH studies. The BREACH I studies investigated geomorphology, sedimentation, and vegetation at four reference and six restored tidal wetland sites in the Delta, and included fish and invertebrate sampling at one reference and three restored sites in the Delta (Simenstad et al. 2000b; Grimaldo et al. 2004). The BREACH II studies expanded this research into Suisun Bay and San Pablo Bay. BREACH I had limitations with respect to assessing benefits of the marsh to fish due to the lack of suitable habitat study areas, a low number of sampling sites, and difficulties of sampling in marsh vegetation. Unfortunately the marshes in the BREACH I studies are not representative of the large historic marshes of the Delta. Most study sites are small and severely altered areas along the edge of levees or on small channel islands. In spite of these limitations, the work done to date has provided meaningful information. The studies included fish assemblage and diet analyses which give some insight into fish use and foodweb structure. Relative density of native fish was shown to be higher at a reference marsh than at three restored marsh sites (Simenstad et al. 2000b). Also, overall ichthyoplankton abundance was highest in marsh edge habitat when compared to shallow open water and river channels (Grimaldo et al. 2004). It will be difficult to adequately address information needs for tidal marsh in the Delta until large-scale restoration is implemented. An upcoming ERP project, BREACH III will further investigate tidal marsh habitats in the north Delta.

Saline and Brackish Tidal Marsh

Through the work of multiple entities, including ERP, large amounts of saline tidal marsh has been restored in San Pablo Bay. Over 3500 acres of formerly diked baylands were restored to tidal circulation in the estuarine reach of the Napa River. Hundreds of additional acres have been restored along other tributaries to the bay. Much more marsh restoration has been planned for the saline portion of the estuary. Land acquisitions have provided the potential to meet ERP acreage objectives for saline tidal marsh. Acreage targets for brackish tidal marsh wetlands in Suisun Bay will most likely be realized through the Suisun Marsh Implementation Plan, which has received funds from ERP. Three site specific restoration planning projects in Suisun Bay received ERP funds during Stage 1.

In the saline tidal marshes of San Pablo Bay, investigations have compared fish use of small channels on marsh plains versus deep water habitats adjacent to the marsh and fish use of marsh channel systems of different stream order. In a five year study of tidal marsh habitats of the Petaluma River and Napa Marsh, Hieb and DeLeon (2000) found native fish to be more common in small marsh plain channels than in adjacent deep water habitats. Native fish dominated the small channels of these two marsh systems, composing 72% and 63% of the catch, respectively. Striped bass and American shad were more common in deep water channels but absent from smaller first, second, and third-order channels (Hieb and DeLeon 2000). In a 95 acre natural tidal wetland in San Pablo bay, higher-order channel systems were found to support greater species richness and densities of juvenile fishes than low-order systems (Visintainer et al. 2006). Analyses of stomach contents of staghorn sculpin revealed a greater variety of prey and higher stomach fullness scores for fish from higher-order systems (Visintainer et al. 2006).

Research has shown clear benefit to native fish of tidal marsh in the saline portion of the estuary, but further studies are required in order to fully address the information needs listed above. In the freshwater portion of the Delta, fish use and benefit of tidal marsh is less clear and further investigation will require large-scale restoration that includes monitoring and research.

U.S. Geological Survey (USGS) created a GIS tool to assist environmental managers in addressing concerns regarding the remobilization of buried and sometimes contaminated sediments in the San Francisco Bay (Higgins et al. 2006). Approximately 400 million cubic meters of mining debris associated with elevated mercury levels were deposited in North San Francisco Bay during the 1800s, and the model reveals that about half of this deposition remains on the bay floor (Higgins et al. 2006). San Francisco Bay Conservation and Development Commission developed a Long Term Management Strategy (LTMS) for the placement of dredged material in the San Francisco Bay region was developed and implemented (Goldbeck and Ross 2007). Today the LTMS agencies are halfway through the transition to low in-Bay disposal volumes and significant beneficial reuse. The Sonoma Baylands project was constructed using dredged material, the Montezuma Wetlands project is accepting material, the Hamilton Wetlands project is coming online, and dredged sand is being used to directly nourish Ocean Beach (Goldbeck and Ross 2007). There is a comprehensive testing program for dredged material, and an interagency Dredged Material Management Office coordinates permit applications.

The first of the Breach Series of investigations, *Applied Research to Predict Evolution of Restored Diked Wetlands* (ERP-96-M10), examined restoration trajectories on diked and subsided lands breached in the Bay-Delta. At this early time in Stage 1 implementation the researchers reached three preliminary conclusions: that invasive species would predominate restorations; elevation change due to ambient conditions would be 1-4 cm per year; and more restricted specialists in the food web would not rebound until the later stages of ecosystem recovery. The work in the Breach series has been continued by a second (*Understanding Tidal Marsh Restoration Processes and Patterns: Validating and Extending the "BREACH" Conceptual Model* (ERP-99-B13), and soon to be third, ERP project.

An ERP-funded study of methods for reversing subsidence on Delta islands (*Demonstration of Techniques for Reversing the Effects of Subsidence in the Sacramento – San Joaquin Delta: Phase I – Twitchell Island* (ERP-98-C01) came to the following important conclusions: 1) initially high DOC loading due to wetland creation on subsided islands would diminish, within 7 years, to less than current levels; 2) rice straw may be a practical method for enhancing accretion rates on subsided delta islands that are still farmed; and 3) reliance on mineral sediments as fill materials is impractical due to compaction and depressed in situ biomass accumulation. This study also conducted research on DOC and THMP loading from flooded and restored Delta islands.

Rhode Island Floodplain Management and Habitat Restoration – Phase I (ERP-98-F09), at very little cost, documented a trend towards increasing elevation of a flooded and subsided Delta Island since acquisition by the state in the early to mid 1980's. Baseline bathymetric and biological data was gathered, and there may be value in follow-up monitoring for passive subsidence reversal and habitat trajectories. The conclusions of this report generally support the accretion conclusions of the Breach project discussed above.

In-channel island restoration and prevention of the loss of relict natural islands, were the subject of two projects funded in the central and west Delta. *Phase II: Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands (Construction & Monitoring)* (ERP-01-N13) and *Demonstration Project for the Protection and Enhancement of Delta In-Channel Islands* (ERP-97-N11) developed and or tested 14 biotechnical structures and identified opportunities and constraints for protection of DICI in the Central and West Delta. The interpretive report found that site specific tule population status and trends are good measures of success of biotechnical fixes. The structures used in these projects did not facilitate sediment accretion. Larger equipment than was used would have been needed to install the size of biotechnicals required for sufficient protection and durability.

Franks Tract State Recreational Area Wetlands Habitat Restoration (ERP-97-N12) and *Feasibility Study of the Ecosystem and Water Quality Benefits Associated with Restoration of Franks Tract, Big Break, and Lower Sherman Lake* (ERP-01-C05) produced engineering designs based upon more conventional, resource intensive, imported material approaches to island creation and protection. The typical alternative from those scenarios would have cost from 5 to 25 million dollars for relatively small areas of restored wetland or upland in the Delta.

<u>Potential Future Activities in the Delta and Suisun Planning Areas:</u>

- Hill Slough habitat restoration (Suisun Marsh)
- Mien's Landing restoration (Suisun Marsh)
- Blacklock restoration monitoring (Suisun Marsh)

- Suisun Marsh Property Acquisition and Habitat Restoration (misc. unidentified [last year] properties) – continue property acquisition, restoration, and monitoring activities for lands suitable for tidal restoration; these will be approved through the Proposal Solicitation Process. Estimated cost of $990,133 for these activities.
- Cache Slough complex
  - Restoration of open water, shallow subtidal, and intertidal habitats on Hastings Tract, Prospect and Liberty Islands, Little Egbert Tract, and the lower Yolo Bypass.
  - Acquisition and planning for restoration of Peterson Ranch property along Lindsey Slough – this 1,600 acre parcel located just (south?) of Calhoun Cut Ecological Reserve is a critical acquisition toward meeting ERP's goals of restoring intertidal habitat, and re-establishing a connection to a historical wetland, in addition to accommodating a rise in sea level. The ERP has tentatively approved $5,989,384 for Solano Land Trust to acquire and plan for restoration on this property.
- Implement and study the planned Dutch Slough restoration project, which would restore up to 483 acres of emergent wetland (a portion of which would be tidal) in the Delta, and generate information on how to best restore tidal marsh habitat. Lessons learned from restoration experiments at this site can be used to restore additional needed marsh areas during Phase 2 throughout the Delta.
- BREACH III/COYOTE project: Continue lower Yolo Bypass technical site evaluation, monitoring, research, and feasibility assessment to greatly improve our understanding of aquatic species' response to tidal wetland restoration. BREACH III component will undertake physical and geomorphic process evaluation, and COYOTE portion will monitor connectivity and key ecological variables (comparing Yolo Bypass and Cosumnes River systems) to assess project performance and the impacts of seasonal and interannual hydrologic variability. Results should be a comprehensive monitoring and research approach that should greatly improve ability to make sound decisions re future management, restoration potential, and flood control needs in the lower Bypass. *[note: this also relates to "floodplains and bypasses" uncertainty]*
- Conduct studies to determine whether fish use and benefit from tidal marsh that has been demonstrated in the saline portion of the estuary is also true for the freshwater portion of the estuary.
- Study OCAP-mandated mitigation to determine whether this is sufficient to adequately mitigate for CVP/SWP export impacts, or whether more marsh is needed

7. CONTAMINANTS

The Bay-Delta ecosystem receives a large variety of potential toxicants, including selenium from agricultural practices, pesticides from agricultural and urban use, mercury from gold mining and refining activities, polynuclear aromatic hydrocarbons (PAHs) and methyl tertiary butyl ether (MTBE) from automobiles, and metals from mining. In addition, high water temperatures and low dissolved oxygen levels threaten habitat suitability for a wide range of species. Synergistic effects of multiple contaminants must also be considered.

Contaminant loadings from the Delta watershed have a significant effect on Delta ecosystem. Pesticides applied in agricultural and residential landscapes, metals an toxins from cars and industrial facilities, mercury from historic mining activities, selenium from San Joaquin Valley agricultural drainage, ammonia and other nutrients from sewage outfalls – all have a substantial impact on the living organisms of the Delta. Controlling these contaminants at their sources must be an important component of ecosystem restoration.

Many water quality issues are difficult to assess because they involve expansive, complicated, and evolving issues that require long-term solutions and continuous improvement. In general, preliminary research results indicate that water quality issues are impacting species although the magnitude of the impact is unknown. Preliminary results indicate impacts to migration (dissolved oxygen, pesticides), reproductive effects to fish and birds (mercury, selenium, organochlorine pesticides), and both sediment and water column toxic episodes (pesticides, toxicity of unknown origin). Work has begun to address source control or other management options to reduce impacts from many of these issues. Examining the relationships between contaminant exposure and effects on organisms is critical to our understanding the links between the two

The Central Valley Regional Water Quality Control Board (Regional Water Board) is the agency charged with protecting water quality in the Delta and its watershed. Adequate staff to support the Regional Water Board's work is key to success in improving Delta water quality, including:

- developing a regulatory approach that can expeditiously address emerging contaminant
- problems as they are identified.

- implementing advanced treatment at all wastewater treatment plants discharging to Delta source waters and implement source control programs for their service areas,

- implementing best management practices (BMPs) and source control necessary to meet water quality objectives,

- implementing BMPs for agricultural discharges to reduce pesticides and other contaminant loads,

- implementing BMPs for all agricultural activities,

- developing land use planning policies that ensure adequate protection of waterways
- from non-point source contamination, including mandatory buffer areas between urban or agricultural development and waterways to allow percolation of run-off.

- Encouraging infiltration into the soils at or near points of precipitation reduces flood flows, slows down the release of water into streams, and can improve water quality. Management and infiltration of stormwater must become a high priority throughout the Delta watershed in order to manage flood risks, recharge aquifers, and help prepare for climate change.

Selenium

Selenium is a naturally-occurring metal, but it is mobilized from soil and enters the surfacewater via irrigation return flows and groundwater. Selenium is also contributed from refineries in the San Francisco Bay area. Recent work has evaluated sources, fate and transport, bioaccumulation and ecological effects of selenium in the aquatic ecosystem, developed treatment feasibility studies and treatment technologies to reduce selenium and salinity inputs in the San Joaquin River watershed, studied the effects of selenium bioaccumulation on sturgeon, and provided support for the planning, development and operation of a real-time water quality management program.

Further participation with the Regional Water Boards is needed to implement TMDLs for selenium, including financial support. Of particular importance are:

Conducting selenium research to fill data gaps in order to refine regulatory goals of source control actions and determine bioavailability of selenium under several scenarios

Expanding and implementing source control, treatment, and reuse programs, including real-time management, if appropriate

Coordinating with other programs; e.g., recommendations of San Joaquin Valley Drainage Implementation Program, CVPIA for retirement of lands with drainage problems that are not subject to correction in other ways

Supporting implementation of TMDL for selenium in the San Joaquin River watershed (focus on Grassland area).

Pesticides from the Sacramento and San Joaquin Watersheds

Key advances have been made in the systematic study of the distribution and abundance of contaminants in the estuary and on defining contaminant exposures in the Sacramento and San Joaquin Rivers and the Delta, although it is still difficult to assess the overall risk that contaminants pose to the health of individuals and populations in the estuary or upstream of the tidal portion of the ecosystem. We have also expanded our knowledge of the degree of contaminant exposure to aquatic organisms, the link between exposure and sublethal and chronic toxicity, and exposure-effect relationships in the waterways of the Bay-Delta.

Pesticides such as chlorpyrifos, diazinon, and pyrethroids have been widely detected in Central Valley surface waters. Early efforts to reduce water contamination by pesticides focused on the widely-used OP pesticides such as diazinon and chlorpyrifos because of their wide use and detection in Delta waterways. However, as OP toxicity received increasing attention from the Central Valley Regional Water Quality Control Board (CVRWQCB) and other regulatory agencies, the use of pyrethroids increased. Efforts then shifted to developing detection methods for pyrethroids to help address this shift in use patterns.

The increased used of pyrethroids in agriculture and urban environments could result in a long-term water quality problem, especially under conditions of reduced light, low microbial activity, low oxygen and high organic carbon content, conditions frequently found in Delta waterways. While combinations of pesticides are often present concurrently in Central Valley waterways, most combinations of two pesticides exhibit simple additive toxicity, rather than synergy or antagonism.

Consistent water quality monitoring is essential to identifying and reducing the impacts of contaminants to aquatic ecosystems. Toxicity Identification Evaluation (TIE) procedures have become an essential tool for identifying the cause of unknown toxicity. TIE "fingerprints" have been developed for priority chemicals widely used in the watershed and often detected in surface waters, including the insecticides carbaryl, azinphos methyl, and malathion and the herbicides chlorothalonil, oxyfluorfen, and trifluralin, and diuron.

The use of pesticide Best Management Practices (BMPs) and Integrated Pest Management (IPM) has increased due to efforts to improve water quality. Pesticide use has also been reduced in areas with more outreach and education, such as that provided by the University of California Cooperative Extension. While OP pesticides continue to cause toxicity to aquatic life, acute effects are now largely limited to agricultural drains and small creeks.

Mercury from Mines and Other Sources

Methylmercury is formed from inorganic mercury which enters the estuary from legacy mining pollution in tributaries by the action of anaerobic bacteria and organisms that live in aquatic systems. It is the most biologically available form of mercury and it bioaccumulates up the food web to higher trophic level fish, with documented adverse health and reproductive impacts to fish-eating birds and humans. Reducing methylmercury production is key to reducing its concentrations in Delta waterways.

Management tools to minimize methylmercury formation include:

- participation in the Central Valley Regional Water Quality Control Board's Total Maximum Daily Load (TMDL) program for mercury and methylmercury in the Delta

- o development and implementation of TMDLs in areas upstream of the Delta to reduce loads of organic and inorganic mercury entering the Delta from tributary watersheds,

- o development of Best Management Practices (BMPs) to control the production of methyl mercury at aquatic habitat sites, and control the transport of methyl mercury into the system.

Temperature Effects on Habitat Suitability

Water temperature is a major factor in habitat suitability for aquatic organisms and unnaturally high water temperature is a stressor for many aquatic organisms, particularly because warm water contains less dissolved oxygen. Lower water temperatures also hinder the success of non-native species, thus reducing predation and competition for food and habitat. Major factors that limit water temperature contributions to the health of the Bay-Delta are disruption of historical streamflow patterns, loss of riparian vegetation, stored water releases from reservoirs, and discharges from agricultural drains.

Numerous fish and wildlife agencies and water resource agencies have collaborated through the Federal Energy Regulatory Commission's Relicensing processes to reevaluate flow and water temperature standards. The newer standards are typically better for aquatic resources.

Other state and federal efforts to better manage water temperatures include:

- o Department of Water Resources' operation of Lake Oroville to satisfy DFG hatchery and stream temperature objectives.

- o Bureau of Reclamation's operation of Central Valley Project reservoirs to achieve specific temperature criteria for salmon and steelhead.

- o Federal Energy Regulatory Commission's regulation of minimum flows below hydropower projects throughout California.

- o State and Regional Water Quality Control Boards' administration of water rights and water quality objectives for beneficial uses.

- o USGS's measurement of streamflow and temperature to provide data necessary for adaptive management of stream temperatures.

<u>Potential Future Activities in the Delta and Suisun Planning Areas</u>

- Continued investigation into development of BMPs to control transport of methyl mercury from restored wetlands

- Possible assistance in Cache Creek Settling Basin to undertake improvements to reduce the amount of methyl mercury entering the Yolo Bypass and Delta. [Estimated cost of $4.6 million for these first two projects]
- Characterize the impacts of upstream San Joaquin River algae loads on dissolved oxygen in the Stockton Deep Water Ship Channel
- Continue to coordinate with the State Water Resources Control Board and Central Valley and San Francisco Regional Water Quality Control Boards' comprehensive five-year strategic work plan for the Delta, including TMDL implementation and miscellaneous water quality studies.
- Participate in a comprehensive monitoring program, including collection and analysis of water quality data.
- Examine the relationships between contaminant exposure and organism effects, and the magnitude of these effects in terms of population impacts.
- Investigate the possibility of synergistic (rather than additive) impacts of multiple contaminants on species.
- Study and characterize the potential effects of ammonia on primary production and on aquatic species in the Delta.
- Conduct selenium research to fill data gaps in order to refine regulatory goals of source control actions, and determine bioavailability of selenium under several scenarios

8. Beyond the Riparian Corridor

Acquiring or managing lands beyond the riparian zone can have multiple benefits. Upland habitat can be used to: (1) expand functional floodplain to allow for natural flooding and stream meander; (2) create a buffer against sea level rise and future flooding; and (3) provide habitat for a number of native species at risk or in decline. Habitat types beyond the riparian corridor, that support species of concern, include inland dune communities in the vicinity of the Antioch Dunes National Wildlife Area, seasonal wetlands (vernal pools, flooded agriculture fields, or other managed wetlands), and perennial grasslands. A number of native species found in these upland areas such as waterfowl and game birds, Swainson's hawk, and greater sandhill crane appear to thrive in certain agricultural lands managed to benefit wildlife species. California tiger salamander and western pond turtle also use various types of managed agricultural land in some phase of their life cycle. Other species that use upland habitats, such as salt marsh harvest mouse, valley elderberry longhorn beetle, giant garter snake, and Lange's metalmark butterfly, have much greater habitat specificity and have thus suffered population declines or extirpations from past disturbances and habitat alterations in upland habitat.

We are faced with several uncertainties that make assessing habitat and species use of upland habitats and planning restoration and subsequent management difficult. These uncertainties include: (1) determining natural versus human induced responses; (2)

effects from agriculture and urban areas; (3) future agriculture expansion and urban development; and (4) effects of climate change.

It is often difficult to determine the extent to which the status and trends of particular species populations are controlled by natural variability, and to what extent they are the product of human disturbances. Consequently, it is difficult to know if observed changes in the ecosystem are caused by restoration and management actions or if they are driven by conditions beyond human control. Developing a better understanding of species-habitat interactions, species-species interactions, and species responses to variable ecosystem conditions is essential to make efforts to recover sensitive species more effective (CALFED 2000c). This is especially true in upland areas beyond the riparian corridor.

Dutch Slough Tidal Marsh Restoration Project (ERP-02-C07-D) estimates that it can restore up to 197 acres of Mixed Riparian-Oak Woodland. The Dutch Slough site was acquired by DWR in 2003. DWR and its partners have completed a restoration plan that is designed both to restore habitat and generate information about how best to restore Delta habitat in the future. The project is ready for implementation.

Full implementation of Northwestern Delta - Jepson Prairie Restoration Phase II (ERP-02D-P54 and ERP-02-P21) would acquire conservation easements on 1,100 acres of existing riparian, wetland and/or agricultural lands.

Department of Water Resources (DWR) completed the vegetation mapping portion of the Stage 1 expectation for the main stem of the San Joaquin River (RM 267 to RM 118). DWR identified, described and mapped the extent and diversity of riparian habitats found along the main stem of the San Joaquin River, to help develop a map of restoration potential along the river (Moise and Hendrickson 2002). Vegetation was classified using a modified Holland system (Holland 1986). Eleven basic vegetation communities were found along the San Joaquin. Such GIS layers as: vegetation/land use, weedy invasives, corridor width (distance between confining levees or bluffs), and georectified aerial photography were created. Of 59,941 acres of riparian corridor and floodplain mapped, about half is native or naturalized vegetation; while the remainder is urban, disturbed, cultivated, or open water (Moise and Hendrickson 2002). Overall cover of woody vegetation (forests, woodlands, and scrubs) is approximately 25% of the total natural vegetation mapped. Of this, a mere 3,809 acres is actually riparian forest (Moise and Hendrickson 2002). The majority of the remaining acreage is covered by herbaceous vegetation (Moise and Hendrickson 2002).

In California, ecosystem restoration actions are often the neighbor to agricultural and urban areas. We should improve and quantify our understanding of how areas adjacent to riparian zones, in particular agricultural and urban lands, influence ecological health. We do not currently know how most species respond individually to disturbances such as crop and dryland agriculture, land development, and invasion of non-native species in these upland areas adjacent to riverine systems. Important questions remain about how agricultural practices can be enhanced or modified to improve ecological conditions and species health. Pilot scale projects on alternative pest management and fertilizer practices; cropping patterns; the use of no-till agriculture; winter flooding; and the establishment of buffer zones around cropped areas, among other things; could yield information about how best to implement these types of practices on a large scale and quantify the benefits associated with them (CALFED 2000c).

Much of the Bay-Delta is under agricultural and some urban development. Persistent pressures for further urban development remain. Westoff et al. (2007) determined that at least 75,000 acres of land within or adjacent to the Delta was at risk of urbanization. Some agree that urbanization in the Delta is a "bad idea" given rising concerns over the increased risk of floods, natural catastrophic events, economic loss, diminished water quality, and loss of wildlife habitat (Lund et al. 2007). Not only do we have direct habitat loss from development, but we also lose valuable habitat connectivity as developed areas increase. Certain agricultural and upland areas are important for maintaining connectivity between adjoining habitats. These areas have the potential for future ecosystem restoration to enhance habitat connectivity and many are currently at risk of urban development (CALFED 2000c). Conservation or agricultural easements to preserve the current land use are potential options, although this must be done through landowner cooperation. Another significant concern remains over the potential third party impacts to areas adjoining restoration lands. Rural and agricultural communities are the most likely to be affected by large-scale restoration actions, and there are concerns regarding the potential for adverse economic and regulatory effects from converting agricultural lands to ecosystem restoration areas (CALFED 2000c).

TNC funded research that examined local landowners, concerns regarding riparian restoration contributing to pest populations and resulting in crop damage. Golet et al. (2007) studied small mammal distribution and abundance at four habitat types (agricultural, young restoration, older restoration, and remnant riparian) on the middle Sacramento River. They found that although certain orchard pests (especially voles) had relatively high abundances at young restoration sites, these declined as sites matured. Overall, relative abundance of small mammal pests was typically lower in older restoration sites and remnant habitats than in agricultural sites. In young restoration sites, voles could be controlled by erecting Barn Owl nest boxes, as voles are their most common prey. A conservation concern was the high relative abundance of exotic black rats (Rattus rattus), a predator of songbird nests and roosting bats, in older restoration sites and remnant riparian forests (Golet et al. 2007).

Geomorphic Model for Demonstration and Feasibility Assessment of Setback Levees: Bay-Delta River Systems (ERP-99-N18) used a meander migration model to examine the relationship between setback distance and habitat formation through a measure of the land reworked over one hundred years of channel migration and cutoff events under different setback levee scenarios on a 28 km reach of the Sacramento River. The study section showed complete cutoff restriction at distances less than about one channel width (300 m), and showed no cutoff restriction at distances greater than about three channel widths (700 m). Three basic patterns of rate of land reworked based on different migration and cutoff dynamics were apparent – complete restriction of cutoffs, partial restriction of cutoffs, and no restriction of cutoffs. Results suggest that management decisions concerned with land reworked could usefully identify the site-specific “restriction of cutoff” thresholds to optimize habitat benefits versus cost of acquired land.

Gaining and maintaining public support is important to the future of ecosystem restoration of riparian systems. In addition to the values of biodiversity and healthy natural systems, large segments of the public look for specific benefits that affect their everyday lifestyle, such as recreation opportunities (Werner et al. 2007). TNC in partnership with EDAW developed two public recreation plans that were tied to the conservation of riparian habitat in Colusa County (Werner et al. 2007). Through an intensive public engagement process, local consensus on these plans was achieved in an area which has not traditionally supported ecosystem restoration efforts (Werner et al. 2007).

Because it heightens the uncertainties already discussed, the regional effects of climate change should be considered in future Bay-Delta scenarios. According to recent predictive modeling we can expect to see a dramatic shift in the hydrograph resulting from changes in the precipitation pattern. With a warming climate California will see more rain and less snow, shifting peak runoff periods from spring to winter, making winter runoff events more frequent and intense (Lund et al. 2007). We can also expect to see a 1-3 feet rise in sea level over the coming century (Mount 2007, Lund et al. 2008). In addition to inundating adjacent lands, sea level rise will increase the frequency and duration of extreme high water events, all of which place additional stress on the already weak levee system (Lund et al. 2008). The habitats and species that use the Bay-Delta will require space to respond to increased pressures from sea level rise and regional climate change. Upland areas can serve as buffers for tidal intrusion, provide a refuge site for animals during extreme high tide events, accommodate additional flood flows in new and/or expanded floodplain areas, and allow for natural succession to intertidal habitats in the future.

Potential Future Activities in the Delta and Suisun Marsh Planning Areas:

- Develop a better understanding of species-habitat interactions, species-species interactions, and species’ responses to variable ecosystem conditions in order to better determine natural versus human-induced responses of upland habitat restoration.
- Determine effects of agriculture and urban areas, and anticipate future effects from expansion of these land uses in the future.
- Plan for the effects of climate change.

9. X2 Relationships

In the 1990s, positive relationships were identified between the historical abundance or survival of several fish and invertebrates and freshwater flow (Jassby et al. 1995). A salinity standard known as X2 was put in place in 1995 and compliance with the X2 standard is key factor in water project management.

Over time, some of the X2-fish relationships have changed. Establishment of the overbite clam (*Corbula amurensis*) reduced the phytoplankton biomass available for zooplankton and in turn may have reduced food supplies for young fish. For those X2 relationships which remain intact, the fish indicator variables have been lower recently for a given X2 condition. While many species appear to benefit from the flow and associated salinity distribution, the aspect of ecosystem function that provides the benefit is likely not the same for all species, given the life history differences and that some reside year-round in or near the Delta (e.g. delta smelt) whereas others range farther downstream, including to the ocean (e.g. longfin smelt, starry flounder, bay shrimp). Potential mechanisms include variation in the amount of suitable habitat provided and circulation patterns that retain organisms in the estuary or concentrate biological production in a low salinity zone. Mechanisms responsible for X2 benefits to species still are not fully understood. Monismith (1998) summarized presentations and discussion at a 1-day workshop at which new information was presented and various hypotheses about the importance of X2 for Bay-Delta species were debated.

Research, data analysis and modeling have continued in an effort to increase understanding of mechanisms underlying the X2 relationships. Such understanding will be crucial to evaluating ideas to modify the X2 standard to improve effectiveness and/or efficiency. Since the Ecosystem Restoration Program Plan Strategic Plan for Implementation was written in 2000 many articles have been published on X2 and how it may be influencing fish abundance.

Monismith et al (2002) described the physics in the estuary associated with the flow – X2 relationship. Kimmerer (2002 a) described the long-term relationship of flow to abundance of higher trophic level organisms (fish and shrimp), including years after the spread of *Corbula amurensis* in 1987. He noted that the relationships did not occur through upward trophic transfer, as flow/abundance relationships were not apparent in data for lower trophic level organisms, and hypothesized that fish abundance variation may occur through physical habitat attributes that vary with flow.

Kimmerer (2002 b) points to lack of clarity regarding X2 mechanisms and need for further investigation. Dege and Brown 2004 Find larval and juvenile fish distribution for most of the 6 species studied , including delta smelt and longfin smelt, is strongly linked to outflow conditions (located closer to the Golden Gate at higher outflow) but their distribution with respect to X2 was not affected by outflow. They found no obvious relationships between outflow and annual abundance indices from the 20 mm survey begun in 1995. Kimmerer and Bennett (2005) reviewed the history of development of the X2 standard, its physical basis and observed biological responses, three potential mechanisms (transport, food, and habitat), and described species-specific considerations and a research plan for identifying mechanisms. Feyrer et al. (2007) identified a decline in fall habitat suitability for three species in recent decades. For delta smelt the factors were increased water transparency (Secchi depth) and increased specific conductance, the latter likely due to decreasing river flow into the estuary in the fall.

Ongoing ERP-funded work by Kimmerer and others has included investigations of X2 - habitat relationships for various species, with habitat defined by salinity and in some cases salinity and depth. The relationships of habitat to X2 appeared consistent with X2-fish abundance relationships for striped bass and American shad, but not for other species. A manuscript is in preparation.

ERP also funded application of hydrodynamic simulations and particle tracking models to investigate the potential role of gravitational circulation in facilitating the upstream movement of bottom-oriented life stages of species that reproduce outside the estuary (in the ocean) but rear in the brackish water area (LSZ) of the estuary (starry flounder, bay shrimp)(Kimmerer et al, unpublished). Results of this work suggest it is plausible that this mechanism may account for the X2-abundance relationships for these species by increasing the rate of travel to the nursery habitat and decreasing the distance to it, thus reducing mortality during this migration and increasing the number of young that reach the nursery ground at higher flows.

The evidence continues to indicate the importance of X2 for a number of estuarine species. For some species the likely mechanisms have been identified, whereas for others mechanisms remain unclear. In addition to the spring, X2 in the fall may be important for some species.

Potential Future Activities in the Delta and Suisun Planning Areas:

- Continue to study the developing evidence in support of the importance of X2 for a number of estuarine species.
- Investigate whether the mechanism of gravitational circulation (in facilitating upstream movement of bottom-oriented life stages of species that reproduce in the ocean but rear in brackish area of the estuary) accounts for the X2-abundance relationships, by increasing the rate of travel to nursery habitat and decreasing distance to it (reducing mortality during migration and increasing the number of young reaching the nursery habitat at higher flows).
- Determine X2 mechanisms for species for which such mechanisms have not yet been identified.
- Determine the importance of X2 in the fall, as well as spring, for some species.

10. Decline in Productivity

At the time of the ERP Strategic Plan (CALFED 2000), the northern San Francisco Bay and Delta had been experiencing a long-term decline in productivity, with a dramatic reduction following the introduction of the non-native overbite clam (*Corbula amurensis*) in 1986 (Kimmerer et al. 1994, Kimmerer and Orsi 1996, Lehman 1996, Jassby et al. 2002). Some, but not all, of the recent decline in productivity could be attributed to the introduction of *Corbula*. The decline in productivity in the northern San Francisco Bay and Delta was accompanied by decline in several species of higher trophic groups, including mysids and longfin smelt. This suggests that a reduction in carrying capacity occurred for some species of higher trophic levels, due to food limitation. Therefore, recovery of populations might be limited by food production.

Several uncertainties regarding the decline in productivity were identified in the ERP Strategic Plan:

- How much of the decline in productivity is attributable to *Corbula* and what other factors may be affecting productivity?
- Has the decrease in productivity resulted in a reduction in carrying capacity for higher trophic levels?
- How much effect would more frequent inundation of floodplains and bypasses have on estuarine and riverine productivity?
- Will restoration projects (including tidal wetlands and riparian) contribute to an increase in productivity and exchange with open water habitats?

Because of limited knowledge on the different sources of decline in productivity and the effects of the decline on higher tropic levels, early efforts were to focus on monitoring and research. Suggested projects to address uncertainties included:

- Research examining role of introduced species on foodweb dynamics.
- Research to identify and examine other potential factors affecting productivity (e.g. contaminants).
- Research examining the role of floodplains and bypasses in providing increased production to the estuary and nutrients that stimulate increased estuarine productivity.
- Research investigating the role of geomorphic processes and riparian vegetation on aquatic invertebrate production, and the affect of this on fish survival and growth.
- Monitoring at restoration sites to evaluate the contribution to estuarine productivity (e.g. tidal wetlands).

Continued research on the effects of *Corbula* on the foodweb of the Delta and northern San Francisco Bay showed that *Corbula* continues to have a significant effect on the ecosystem (Kimmerer 2002a, 2004). The decrease in phytoplankton caused by *Corbula* has had variable effects on species of higher trophic levels. Longfin smelt showed the greatest declines. The abundance of Delta smelt did not change following the introduction of *Corbula* (Kimmerer 2004), although individual delta smelt were often food-limited (Bennett 2005). However, a reduction in mean length in Delta smelt may be related to the reduction in productivity. The effect of the decline in productivity on higher trophic levels may have been dampened by the departure of northern anchovy from the upper estuary following the invasion of *Corbula* (Kimmerer 2006).

Kimmerer (2002a) described the long-term relationship of flow to abundance of higher trophic level organisms (fish and shrimp), including years after the spread of *Corbula* in 1987. A hypothesized mechanism for this relationship was an increase in available food with increases in flow. Kimmerer noted that the relationships did not appear to occur through upward trophic transfer, as flow/abundance relationships were not apparent in data for lower trophic level organisms. These results do not support the idea that carrying capacity has been reduced due to declines in productivity. However, Kimmerer (2002b) pointed to a lack of clarity regarding X2 mechanisms and a need for further investigation.

An ERP funded project to assess the effects of pesticides on juvenile Chinook salmon and their food resources found pesticides at levels toxic to *Hyalella azteca* in sediment samples from many creeks and irrigation channels throughout the Central Valley, suggesting the pesticides may be effecting food resources (Weston et al. 2004). The project also found an increased stress response, and at high concentrations, mortality, in juvenile Chinook salmon exposed to pesticides (Eder et al. 2004).

An ongoing ERP funded project in Suisun Marsh has measured primary and secondary productivity and fish abundance in the marsh and compared these to adjacent open water habitats. The results show that the highly productive brackish tidal marshes provide important habitats to native fish. However, phytoplankton production in marsh channels appears to be limited when *Corbula* is present. Recent studies have demonstrated that tidal marsh restoration would likely increase phytoplankton biomass in the estuary and enhance the planktonic foodweb. In a study of carbon types and bioavailability, tidal marsh sloughs had the highest levels of dissolved and particulate organic carbon (DOC and POC) and phytoplankton-derived carbon (Sobczak et al. 2002). Tidal sloughs were also the highest in Chlorophyll *a* concentration, an important factor in zooplankton growth rate (Müller-Solger et al. 2002). Delta and Suisun zooplankton appear to be food-limited much of the time, due to low levels of phytoplankton (Müller-Solger et al. 2002, Sobczak et al. 2002, Kimmerer et al. 2005). It appears that high residence time of water, nutrient availability, and absence of alien clams contribute to high levels of primary production (Jassby et al. 1993) and empirical studies (Lopez et al. 2006) suggest that productivity from high-producing areas, such as marsh sloughs, is exported to other habitats.

Many studies have shown floodplains to be important to native fish, especially as rearing habitat for juvenile salmon and as spawning and rearing habitat for splittail. Recent research (Lehman et al. 2008) has shown that floodplains have much higher primary production than adjacent river channels and that much of this production is exported to downstream estuarine habitats.

A study investigating the trends and causes of phytoplankton abundance concluded that the trend in primary productivity in the Delta between 1996 and 2005 has been positive (Jassby 2008). This does not support the argument that fish declines (at least those during the POD years) were caused by food limitation. Of course, some other mechanism could be limiting food availability (e.g. contaminant toxicity to zooplankton).

Although much has been learned about the foodweb in the Delta and northern San Francisco Bay, uncertainty remains about the importance of food limitation to native fishes. *Corbula* has certainly had a negative impact on the foodweb of Suisun Bay and the western Delta, but the significance of this to higher trophic levels is still being investigated. It seems likely that an increase in zooplankton in the Delta and Suisun would provide better habitat conditions for fish. However, studies have presented conflicting results on the changes in system productivity and the resulting effect on fish populations. Research seems to support tidal marsh restoration as a means of improving system productivity, but no large-scale restoration project has been completed that could verify this conclusion. Floodplains have been shown to provide important habitat to native fish and to increase estuarine productivity. Ongoing work on the pelagic organism decline (POD) may help to address some of the remaining uncertainties.

Potential Future Activities in the Delta and Suisun Planning Areas

- Continue to study the roles of non-native species (e.g. Corbula) versus contaminant toxicity in the potential declines in food availability for aquatic species
- Continue to study tidal marsh restoration efforts in the Delta and Suisun Marsh to determine whether this restoration improves system productivity
- Potential impacts of ammonia on primary productivity (studies underway by State and Regional Water Quality Control Boards)

11. DIVERSIONS

The ERP Strategic Plan states that the State Water Project (SWP) and Central Valley Project (CVP) large-capacity diversions in the south Delta are a source of mortality for several species, but that it is unclear to what extent this mortality affects populations of these species or other biota, nor by what mechanisms these species and biota are most affected by the pumps. It is acknowledged in the ERP Strategic Plan that mortality from these pumps occurs from both direct (diversion, impingement on fish screens, and the handling of fish during salvage) and indirect (increased predation from being drawn into Clifton Court Forebay, fish being drawn to inferior habitat conditions in south Delta channels, and alteration of migrational cues) effects.

The ERP Strategic Plan notes that the relative importance of the SWP and CVP pumps in contributing to mortality of individuals in a population cannot be ascertained without more information on the importance of other stressors, such as poor water quality or possible entrainment in relatively small agricultural diversions.

In general, these uncertainties remain today; however, much has been learned during ERP implementation about the effects of water diversions on aquatic species and biota. It is still believed that many of the indirect causes of mortality to the Delta's aquatic organisms is due to the hydrologic effects of the pumps within Delta channels (i.e. waterways flowing upstream toward the pumps); these hydrologic effects are believed to have a large impact on juvenile outmigrant and rearing salmonids (e.g. unnatural flow conditions result in longer migration routes, delayed migration, and reduced growth and survival through longer exposure to adverse conditions), as well as pelagic species (NMFS 2007).

In terms of direct mortality to fish from diversions, much has been learned as well. The SWP and CVP export pumps are believed to entrain large amounts of outmigrating and rearing juvenile Chinook salmon (NMFS 2007). Recent analyses correlating SWP and CVP salvage with population indices show an estimated loss rate of migrating juvenile Chinook of 10% or less, depending on pre-screen mortality; while this is less than ocean harvest mortality (which in recent years has been around 40%), from a population perspective, the calculated loss rate at the export facilities is a significant element of direct anthropogenic mortality. However, the unknown level of pre-screen mortality is a limitation in this analysis. Similar analyses for delta smelt show that pre-spawning adults, as well as larvae and early juveniles, may suffer substantial losses; a combination of the results for these life stages indicate delta smelt losses may be on the order of 0-40% of the population throughout winter and spring. Ongoing analysis by the Interagency Ecological Program (IEP) in its evaluation of the Pelagic Organism Decline (POD) asserts that substantial increases in winter SWP and CVP salvage occurred contemporaneously with the recent decline in pelagic species, suggesting that the SWP and CVP diversions played a role in the POD. While delta smelt habitat, food supply, predation, and exposure to toxics could be manipulated to improve its status, manipulation of export flow is thought to be the only feasible means of influencing delta smelt abundance that is supported by the current body of evidence (Kimmerer 2008).

The Contra Costa and Pittsburg Power Plant diversions are believed to have relatively small impacts on rearing and outmigrating juvenile winter-run Chinook salmon and steelhead, and medium impacts on rearing and outmigrating spring-run and fall/late-fall run Chinook (NMFS 2007). The effects of these power plant diversions on pelagic fishes such as delta and longfin smelt have not been ascertained, but nonconsumptive water use by these diversions may approach 3,200 cfs at times, possibly enough to create a substantial entrainment risk. This is a topic that the Interagency Ecological Program (IEP) is currently studying as part of its evaluation of the Pelagic Organism Decline (POD); monthly surveys have been conducted since November 2007, and analysis can begin after a full year of data has been collected (IEP 2008a).

Individual small unscreened agricultural diversions in the Delta are thought to have large impacts on all runs of outmigrating and rearing juvenile Chinook and steelhead (NMFS 2007), but there is not consensus in the scientific community on this point. Detailed study of one small diversion suggested that their effects on delta smelt are small (Nobriga 2004 as cited in IEP 2008b), although the potential for these diversions to entrain eggs and larvae of endemic Delta fish species has not been determined.

A team of State and federal fish screen experts have been holding regular workshops since mid-2007, to share information among State and federal managers implementing the ERP, the Anadromous Fish Restoration Program (AFRP), and the Anadromous Fish Screen Program (AFSP) authorized under the Central Valley Project Improvement Act (CVPIA) and to discuss prioritization of future screening projects. A comparison of the Sacramento River, San Joaquin River, and Delta areas shows that 93% of all diversions in California are unscreened, and that the majority of these unscreened diversions are less than 100 cfs in capacity (DFG 2007).

Screening costs generally range from $4,000 - $30,000 per cfs screened, and for the larger screening projects that are ongoing, the costs are $27,000 - $150,000 per cfs. Infrastructure requirements, increased costs for steel and concrete, labor and transportation to remote sites are driving costs up. Increasing costs, the relatively small size of the diversions, and the limited data that exists for the cumulative effects of small diversions generally dictate that few of the 2,000+ small unscreened diversions in the Delta and Suisun Marsh will be screened in the next 20 years (DFG 2007). However, a prioritized list of criteria for potential fish screen projects has been generated, and will be used to evaluate fish screen projects in the future.

<u>Potential Future Activities in the Delta and Suisun Planning Areas</u>

- Continue participation in the Sacramento Valley/Delta Fish Screen Program, which seeks to reduce entrainment mortality of juvenile fish by installing state-of-the-art fish screens on Sacramento River and Delta diversions; includes collection of monitoring data prior to construction.
- Continue ERP coordination with State and Regional Water Quality Control Board, and IEP, studies and activities geared toward determining the impacts of diversions on various life stages of fish.
- Further investigation of role of E/I ratio as dominant factor in particle fate, in relation to entrainment of pelagic organisms (including eggs and larvae) in SWP and CVP pumps and other diversions. (E/I ratio range of .17 to .35). Salmon smolts may not be accurately captured by this model because their behavior likely makes their fate depart substantially from neutrally buoyant particles such as pelagic species' eggs and larvae.

12. Importance of Delta to Salmon

Anadromous salmonids must travel through the estuaries in their migration to the ocean. Some species seem to merely pass through, while others may spend considerable time in the estuary utilizing it for growth and rearing, and to adapt to the osmotic difference between fresh water and the ocean.

Juvenile chinook salmon seem to be the species that makes the greatest use of the Delta. Chinook have been shown to have highly flexible life history patterns (Moyle 2002, Quinn 2005). Described chinook life history types range from between 2 or 3, to as many as 5 (Clipperton & Kratville *in review*, Quinn 2005). Varied life history strategies allow chinook salmon to exploit highly variable environments (Moyle 2006), survive the highly stochastic conditions they may face in the environment, and may act as a buffer due to losses of segments of the population applying differing strategies (Clippperton & Kratville *in review*). Healey (1991) placed them into two basic life history types, stream type and ocean type, which includes estuarine type described by Reimers (1973). Stream type juveniles rear primarily in fresh water for about a year before leaving the river and spend relatively little time in the estuary as they migrate to the ocean. Chinook ocean types vary considerably in their use of the estuary. They might spend a few months growing in the river first, or move almost immediately to the estuary after emergence to rear (Quinn 2005, Williams 2006).

Other than passage through the Delta, there has been relatively little research on juvenile salmonid behavior within the Delta (Williams 2006). Current and historic records show use of the Delta by salmon and steelhead fry and historically this use was far more extensive than it is today. Although chinook salmon are known to use other estuaries for rearing, there is a level of uncertainty as to the current use and suitability of the Sacramento – San Joaquin Delta for rearing by salmonids. The lack of use of the Delta as rearing habitat may be a behavioral response to the extensive changes in hydrology, water quality, invasive species and loss of habitat in the Delta (Macfarlane & Norton 2002).

Stressors that affect salmonid presence in the Delta

Water quality: Salmon are adversely affected through toxicity and bioaccumulation of pollutants such as nutrients, herbicides, pesticides, suspended sediments, and other contaminants from agriculture and storm runoff from rivers within and above the Delta, and municipal and industrial discharge in the Delta. Hamilton (2003) found that the bioaccumulation of Selenium adversely affects Chinook salmon.

Loss of tidal marsh habitat: Upwards of 95% percent of historic tidal marsh has been lost from the Delta, and much of the approximately 10,000 acres remaining marsh is fragmented into small patches and strips (Clipperton & Kratville *in review*). In a recent paper, *Assessing the potential benefits of tidal marsh restoration in the Delta and Suisun*, Clipperton and Kratville (*in review*) argue the potential benefit to chinook that could come with the careful restoration of tidal marsh habitat the Delta: "*Research in other estuaries has shown the benefit of tidal marsh to native fish to be much more obvious. Native species on all coasts of North America make intensive use of marsh plains and channels for breeding, foraging, and refuge from predators. Very clear increases in foraging success have been shown for marsh channels and surfaces. In the Pacific Northwest, Chinook salmon feed, grow, and adapt to salt water in tidal marsh habitats. Juvenile salmon move far into wetlands on high tides and may return to the same marshes for many tidal cycles. Tidal marshes have been shown to have high insect abundance and juvenile salmon using them have been shown to have the highest stomach fullness scores relative to other habitats. Life-history diversity is greatest in estuaries that have extensive tidal marsh habitat. Life-history types that include estuarine residence result in juvenile salmon that enter the ocean at larger sizes and over a broader range of time. Evidence from the Pacific Northwest suggests that marsh restoration in the Delta would have a large positive impact on Chinook salmon.*"

Invasive species: It is unknown how much of the salmonid mortality in the Delta is due to invasive species, but it is likely significant. Mortality related to invasive species is due to predation by non-native centrarchids and striped bass, and changes in ecosystem function including food availability and cover (Moyle 2002). Invasive species such as

Egeria can also effect water clarity and provide cover for predators (Clipperton & Kratville *in review*)

Food web changes: Juvenile salmonids migrating through and particularly while rearing in the Delta require an ample supply of food, primarily invertebrates, in order to survive and reach the ocean in good condition. NH_4 is one such factor that affects the food web by effecting primary and secondary production in the Delta (Clipperton & Kratville *in review*, Dugale et al. 2007).

Entrainment: Water diversions in the Delta are a source of mortality (Moyle 2002) and may be a significant source of mortality in some areas of the Delta. This source of mortality might be reduced by a combination of screening, and closing or reducing diversions during outmigration periods (Moyle 2002).

Predation: The modification of the delta hydrology including diversionary structures and the removal of cover can make salmon vulnerable to predation by piscivorous birds and non native fishes (Moyle 2002).

Temperature: Water temperature due to low flows by removal of water by diversions, drought and global warming may be a significant source of mortality in the Delta. One estimate of optimum survival was for flows at Rio Vista between 20,000 and 30,000 cfs and temperatures below 17° C (Brandes & McLain 2001). More research is necessary to tease out how the modern configuration of the Delta impacts water temperature.

Competition by hatchery fish:
Hatchery-reared fish might be competing for limited cover and food resources available to wild fish migrating through and rearing in the Delta (Moyle 2002).

Patterns of survival and use of the Delta by chinook salmon

Brandes and McLain (2001) summarized data collected for the Interagency Ecological Program for the Sacramento-San Joaquin Delta (IEP) salmon studies. The authors came up with several conclusions related to juvenile chinook abundance, distribution and survival in the Delta:

- In wet years, many fry enter the Delta and that overall higher juvenile production leaves the Delta in wet years. This may be due to increased fry survival upstream in those years however, because even though more fry migrate to the estuary in wet years, fry survival appears to be lower in the estuary than upriver in high flow years.
- Smolt survival in the Delta decreases as flows into the Delta decrease and water temperatures increase.
- Mortality was highest for marked smolts migrating into the Central Delta through Georgiana Slough or the Delta Cross Channel, and smolts migrating through upper Old River in the southern Delta.

The use of otoliths to determine Delta rearing location and timing

Phillis et al. (2007) are using novel methods of identifying geochemical markers in otoliths of hatchery origin (coded wired tagged) chinook salmon to determine movement through the Delta. They measured $^{87}Sr/^{86}Sr$ concentration in otoliths, water, and from clams along migration paths from the capture sites back through to the hatchery. Preliminary results suggest that this method could allow researchers to determine rearing preferences not only in tagged fish of known origin, but also the rearing preferences, and origin, including whether they are wild or from a hatchery, of adult fish recovered in carcass surveys. The researchers also used Sr/Ca, Mg/Ca and Ba/Ca ratios from otoliths of fish caught in various locations in the Delta. Results so far suggest that Mg/Ca could potentially be used as a marker for Delta entry, Ba/Ca as an exit marker for the Delta, and Sr/Ca might be used as a marker to detect exit from Suisun Bay, but not the Delta. Included with the same report, a separate but related study by the same researchers working on a project called *The role of the San Francisco Bay-Delta in juvenile rearing for winter and spring run chinook salmon*, to *be determined by otolith microchemistry*, the researchers have begun the analysis of $^{87}Sr/^{86}Sr$ concentrations in otoliths of spring and winter run adult spawners collected in carcass surveys, and are getting preliminary results that suggest residence time in natal streams ranging from < 2 weeks to up to 4 months, with most leaving before 40 or after 80 days of residence. Some remained in the main-stem Sacramento River to rear, while others reared in the Delta or proceeded to the ocean. They have also been able to note wild or hatchery origin and straying by some individuals from their natal streams.

Monitoring the use of the Delta by fry

In a poster by Ingram and Wilder (2006), *Seasonal variation in diel activity patterns of chinook salmon in the Sacramento-San Joaquin River Delta* (Ingram & Wilder 2006), the authors related CPUE to the activity of chinook salmon fry in the Delta. Where sampled, they found that activity was greatest diurnally and at crepuscular times of day in the spring (primarily fall-run chinook) and nocturnally and at crepuscular times in the fall (primarily late fall-run chinook). Also, turbidity (secci) was significantly different in the spring vs. fall with water in the spring being more turbid than in the fall. Mean temperature was not significantly different. There was significantly more daylight in spring than in fall, and the mean fork length was larger during late fall sampling than spring sampling.

Migratory behavior in the Delta

The CalFed Project ERP-01-N48 was conducted to improve the understanding of juvenile anadromous salmonid migratory behavior in the Delta. The researchers released radio-tagged juvenile chinook salmon at various locations in the northern and central Delta. Results indicated that predation in some regions of the Delta is higher than in others. Most of the tagged fish used the middle portion of the channels while migrating, they did not clearly hold position on flood tides and migrate on ebb tides, and commonly migrated with the prevailing tidal flow direction.

On the Cosumnes River, there was one project to evaluate and implement construction of structures to improve adult salmonid passage over existing diversion structures in the Cosumnes River: *Cosumnes River Salmonid Barrier Program* **(ERP-98-B25)**. Tasks included evaluating alternatives, finalizing engineering specifications, bidding, and construction.

On the Mokelumne River, there were two projects that conducted feasibility analysis, permitting and design for replacement of the Woodbridge Dam, including new fish ladders, to improve passage on the Mokelumne River: *Lower Mokelumne River Restoration Plan - Phase 1* (ERP-98-B11) and *Lower Mokelumne River Restoration Program - Phase 2* (ERP-01-N57). The new dam and fish ladders currently are under construction, funded by bonds financed by the Woodbridge Irrigation District's sale of surplus water to the City of Lodi.

Adult Fall-Run Chinook Salmon Movement in the Lower San Joaquin River and South Delta (ERP-98-C11) used ultrasonic transmitters to determine: 1) the relationship between fish movements and dissolved oxygen and water temperature, 2) identify milling and straying behaviors, and 3) determine the rate at which salmon travel through the Sacramento–San Joaquin Delta. The study was conducted during one better-than-average rainfall year in the Sacramento and San Joaquin watersheds, which resulted in higher than normal flows which sustained good water quality during the fall salmon run. This study was unable to identify potential barriers related to water quality in the Stockton Deep Water Channel (SDWC) because most of the tagged salmon ascended the Sacramento River and the water conditions in the SDWC appeared to be favorable for salmon passage. The study results suggest that the salmon were not delayed in the SDWC and their average travel times were 2.1 days when the dissolved oxygen levels were above 5.0 mg/l. Several fish moved downstream after being tagged and some fish appeared to roam the Delta before committing to one river system. Most of the salmon tagged on the San Joaquin River exited the Delta on the Sacramento River, which indicates that the fish may be using the Delta Cross Channel and Georgiana Slough to cross back over to the Sacramento River. The salmon behavior was highly individualistic and their migration times and distance traveled were variable.

Based on limited data from the *Juvenile Salmon Migratory Behavior Study in North and Central Delta using Radio Telemetry* (ERP-01-N48) salmon migration study, it may be that a combination of a neap tide, reduced exports, and increased San Joaquin River flows are beneficial for outmigrating smolts; but more research is needed to confirm this. Of particular interest is using recently-developed equipment and analytical techniques to evaluate how fish are diverted at key Delta channels and flow splits by measuring fish movements and flow structure concurrently (Vogel 2004).

<u>Potential Future Activities in the Delta and Suisun Planning Areas</u>

- Continue to study current use and suitability of Delta for rearing by salmonids, particularly in newly restored tidal marsh areas (phase 1 & 2).

- Continue to study how much of salmonid mortality in the Delta is due to invasive species (predation by centrarchids and striped bass), diversions, low food availability, and/or cover supporting predatory fish, and competition by hatchery fish.

** DESCRIPTIONS OF ALL ERP PROJECTS CAN BE FOUND AT HTTPS://NRMSECURE.DFG.CA.GOV/FILEHANDLER.ASHX?DOCUMENTID=4951

Appendix F: Proposed Targets for Ecological Processes, Habitats, Stressors, and Species in the Delta and Suisun Planning Areas

These preliminary targets were compiled from multiple sources, including but not limited to the Delta Vision Strategic Plan Staff Draft #2, the Ecosystem Work Group document dated June 13, 2008, federal Recovery Plans, the ERPP volumes 1 and 2, and professional judgment. They have not been reviewed or approved by State and federal fisheries agencies, and will be updated in the future as additional Performance Measures staff are added to Department of Fish and Game staff.

A more comprehensive set of indicators and targets have been developed for the larger programmatic ERP Conservation Strategy for Stage 2, which will be incorporated into future conservation strategies focused on the Sacramento Valley, San Joaquin Valley, and San Francisco Bay Ecological Management Zones of the ERP as appropriate; however, the indicators and targets contained herein are specifically limited to environmental variables in the Delta and Suisun Planning Area that can be controlled through management actions as the ERP is adaptive managed through 2030.

Indicator	2020	2040	2060
Ecological Processes (Delta Inflows, Outflows, and Hydrodynamics)			
Reestablish more natural internal Delta water flows in channels	Number of "ring" channels or "cuts" blocked to reduce mixing TBD.	No net reverse flows in any Delta channels	No net reverse flows in any Delta channels
Maintain net downstream flows in mainstem SJR from Vernalis to immediately west of Stockton from Sept-Nov to help sustain DO levels and water temps adequate for upstream migrating adult fall-run Chinook salmon	Annually	Annually	Annually
General target is to focus on restoring hydrodynamic patterns typical of those exhibited when the ecosystem was functioning in a healthy state (e.g. 1960s).	Flows by water year type TBD	Flows by water year type TBD	Flows by water year type TBD
Annually provide a fall or early winter outflow coincident with the first "winter" rain through the Delta by limiting water diversions for 10 days.	Flows by water year type TBD	Flows by water year type TBD	Flows by water year type TBD
Annually provide a late-winter or early spring inflow coincident with the early-spring peak inflow from the Sacramento River (~Feb-March).	Flows by water year type TBD	Flows by water year type TBD	Flows by water year type TBD
Annually provide inflow from the San Joaquin River that emulates the spring inflow (~late April – early May).	Flows by water year type TBD	Flows by water year type TBD	Flows by water year type TBD

Net downstream flow on San Joaquin River at Jersey Point (i.e. no reverse flow conditions) Oct 1 to Jun 30	> 0 cfs	> 0 cfs	> 0 cfs
Number of 7-14 day duration fall flow pulses on San Joaquin River at 2,000-3,000 cfs at Vernalis between Sep and Nov each year	1-2	2	2
Number of months between Aug and Nov with Delta outflow of 12,000 – 18,000 cfs	1-2	1-2	1-2
Spring flow targets	TBD	TBD	TBD
Ecological Processes (Bay-Delta Aquatic Foodweb)			
Increase primary and secondary productivity in Suisun Bay and the Delta to levels historically observed in the 1960s and 1970s	> 50% progress toward long-term goal	1960s-1970s levels	1960s-1970s levels
Habitats			
Acres of restored tidal marsh, Delta (not accounting for sea level rise)	15,000	30,000	> 30,000 if warranted by adaptive management analyses
Acres of restored tidal marsh, Suisun (not accounting for sea level rise)	9,000-12,500	25,000	> 25,000 if warranted by adaptive management analyses
Acres of restored shallow open water habitat, Delta (~60,000 acres potential)	TBD	TBD	TBD
Expand the acreage managed as seasonal floodplain in and upstream of the Delta (Yolo Bypass, San Joaquin River, and Cosumnes/ Mokelumne confluence)	30,000	50,000	73,800 (10% of Delta acreage)
Floodplain Activation Flow (FAF) for floodplains on the Sacramento River: Active flooding persists for a minimum of seven days over the period of March 15 to May 15, in two out of every three years (PWA and Opperman 2006). (Measure: frequency of prescribed flooding)	In wet and above normal years	In wet, above normal, and below normal years	> 67% of all water year types
Restore tidal channels in southern Yolo Bypass, while maintaining or improving flood carrying capacity (construct a network of channels within the Yolo Bypass to connect the Putah and Cache Creek sinks, and potentially the Colusa Drain, to the Delta; these channels should effectively drain all flooded lands after	Implement the Yolo Bypass Interagency Working Group Restoration Plan		Acquire necessary easements to allow entire Yolo Bypass to flood at lower flow levels through the

floodflows stop entering the bypass from Sac & Fremont weirs, and would maintain a base flow through spring to allow juvenile anad & resident fish to move from rearing & migratory areas – also, reduce flow constrictions such as those in the railway causeway paralleling I80.			notch in the Fremont Weir
Acres of seasonal wetlands and grasslands	TBD	TBD	TBD
Acres of fall open water habitat between 0.5-6 parts per thousand salinity	large-scale experimental flooding of island(s) to reduce uncertainties	TBD	TBD
Number of functional migratory corridors per river system (Sacramento, San Joaquin, Mokelumne/Cosumnes) (replaces "Amount of channel habitat")	2 per river	> 2 per river	> 2 per river
Attributes of Restored Habitats			
Amount of river miles connected to habitats (replaces "Degree of connectivity")	TBD	TBD	TBD
Distribution of large habitat complexes along estuarine gradients and with extensive internal connectivity	Suisun, North Delta	+ East and South Delta	Throughout Delta
Percent of aquatic food web support by diatoms	TBD	TBD	TBD
Group 6: Stressors			
xFish entrained at Delta diversions, outmigrating juvenile salmonids: percent of population	TBD	TBD	< 2%
Fish entrained at Delta diversions (delta smelt and longfin smelt)	TBD	TBD	TBD
Evaluate effects, and where appropriate, reduce loss of important fish species at diversions by consolidating/screening diversions	TBD	TBD	TBD
Number of new, uncontrolled harmful invasive species	TBD	TBD	TBD
Incidents of migratory passage delays, blockages, or mortalities due to physical barriers, low dissolved oxygen, high temperatures, or toxics	TBD by ongoing State & Regional WQCB efforts	TBD by ongoing State & Regional WQCB efforts	TBD by ongoing State & Regional WQCB efforts
Dissolved oxygen concentrations in anadromous fish migratory corridors at all times	> 5 mg/L	> 5 mg/L	> 5 mg/L
Control of invasive clams (Corbula, Corbicula) (% of 1995-2000 average abundance and distribution)	< 100%	TBD	TBD
Control of Brazilian waterweed (Egeria)	<50%	TBD	TBD

(% of 1990-2000 average abundance and distribution)			
Manage existing and restored dead-end and open-ended sloughs and channels so that the total surface areas of these sloughs and channels covered by invasive non-native aquatic plants is reduced, by conducting large-scale, annual weed eradication programs throughout existing and restored sloughs and channels.	< 1 % of surface area covered by invasive plants	TBD	TBD
Reduce loading, concentrations, and bioaccumulation of contaminants in water, sediments, and tissues of fish and wildlife	TBD by ongoing State & Regional WQCB efforts	TBD by ongoing State & Regional WQCB efforts	TBD by ongoing State & Regional WQCB efforts,
Evaluate operational strategies to reduce loss of juvenile fish in Clifton Court Forebay and reduce predation.	75%-90% reduction in fish losses	TBD	TBD
Species			
Delta smelt and longfin smelt abundance (% of 1967-1983 fall mid-water trawl)	≥ 100%	≥ 100%	≥ 100%
Delta smelt distribution (% of pre 1983 habitat occupied)	> 50%	100%	100%
xSplittail abundance (% of 1987-1991 drought)	TBD	TBD	TBD
VELB: Maintain and restore connectivity among riparian habitats occupied by VELB and within its historic range along the Sac and SJ Rivers and their major tribs	TBD	TBD	TBD
Swainson's hawk: increase current estimated population of 1,000 breeding pairs in the Central Valley to 2,000 breeding pairs (as of 2000)	1,000 breeding pairs	2,000 breeding pairs	Protect, enhance, and increase habitat sufficient to support a viable breeding pop'n
Aleutian Canada goose: % of world's population sustained during winter residence			50%
Tundra swan and white-fronted goose: % of Pacific Flyway population sustained during winter residence			40%
Canvasback: % of Pacific Flyway population sustained during winter residence			20%
Raptors (other than Swainson's hawk) and songbirds: % of existing breeding populations in the Delta			Maintain (100%)
Ducks sustained at peak wintering abundance in Delta and Suisun Marsh combined	≥ 1.4 million	≥ 1.4 million	≥ 1.4 million
Shorebirds sustained at peak witnering	≥ 70,000	≥ 70,000	≥ 70,000

abundance in Delta and Suisun Marsh combined			
Adult salmon, steelhead, and sturgeon migration survival through Delta	TBD	TBD	> 95%
Juvenile salmon, steelhead, and sturgeon migration survival through Delta	TBD	TBD	> 50%

Targets were developed for the ERP Stage 2 Conservation Strategy with information collected from the following sources:

Ecosystem Work Group product dated June 13, 2008
Delta Vision Strategic Plan (Staff Draft #2) (July, 2008)
CALFED Ecological Restoration Program Plan Vol. I & II (2001)
CALFED ROD (2000)
Central Valley Joint Venture
DRAFT Pacific Flyway Data Book (2008)
Giant Garter Snake Recovery Plan (1999)
Riparian Habitat Joint Venture
Williams, J. G. 2006. Central Valley Salmon: A Perspective on Chinook and Steelhead *in* the Central Valley of California. San Francisco Estuary and Watershed Science 4, no. 3 (December): Article 2.
Quinn, Thomas P. 2005. The behavior and ecology of pacific salmon and trout. University of Washington Press, Seattle. 378 pages.
AFRP Final Restoration Plan, 2001. http://www.delta.dfg.ca.gov/afrp/restplan_final.asp#B-1
PFMC Escapements to Inland Fisheries and Spawning Areas; http://www.pcouncil.org/salmon/salbluebook/App_A_Hist_Ocean_Effort_Land.xls http://www.pcouncil.org/salmon/salbluebook/App_B_Hist_Esc_FW_Catch_Spawn.xls
NOAA fisheries goals http://www.calwater.ca.gov/science/pdf/eco_restor_winter_chinook.pdf
DRERIP models (2008)

For all species targets, when overlap in documents occurred, the most recent available information was used. Actions will continues to be vetted and revised as new information occurs, recovery plans are updated and finalized, and DRERIP models are revised.