Ecosystem Restoration Program (ERP)

Conservation Strategy

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

Version 2.0

Prepared by

California Department of Fish and Game
National Marine Fisheries Service
U.S. Fish and Wildlife Service

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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 document should be viewed as a "living document" which will be revised and updated 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 very general overview of how the Ecosystem Restoration Proram (ERP) proposes to address the critical environmental conditions in the Delta and Suisun Marsh/Bay.

There are several key aspects of this document that are expected to change over the course of this year, which will add more detail and justification for specific restoration actions to be undertaken in the near- and longer-term implementation of the ERP over the next ~20 years. Specifically:

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 implementation of this ERP Conservation Strategy focused on the Delta and Suisun Marsh/Bay would be one component of a comprehensive program of governance toward a "sustainable" Delta (i.e. the Delta Vision process). However, these assumptions about ERP governance could change if the Delta Vision process yields a different outcome.

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]) which is further removed from the influence of the south Delta export facilities. Over the longer-term, as the 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 are nearing completion, 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 targets and performance measures. The conceptual models will be used to develop targets and performance measures by which ERP implementation will be evaluated over time. While staffing resources are expected to be augmented to develop specific targets and ecological performance measures in the future, progress on their development to date has been limited to expert judgment as represented in the conceptual models and in work products of related planning efforts (i.e. the Delta Vision Ecosystem Work Group).

Habitat types and locations. Specific habitat types (e.g. intertidal, shallow subtidal, open water) are still being refined in other planning processes in accordance with the ecological functions they serve, and in the interest of consistency among efforts, those changes will be incorporated into this conservation strategy in the future. As these habitat type definitions are refined, the "suitable" and "potentially needed" acreage of each habitat type (Table 1) will change.

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 help inform and prioritize management decisions relating to ecosystem restoration actions in the Delta and Suisun Marsh/Bay.

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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 ERP Focus Area

The purpose of this document is to describe the ERP Implementing Agencies' positions regarding 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.

The CALFED ERP is a 30-year regulatory program with strategic goals and objectives (see Appendix A) that are fundamental to the development of the conservation strategy, which includes objectives for sound science to guide development of monitoring, tracking, and adaptive management. Related scientific study and planning efforts of the ERP Implementing Agencies and other entities will contribute new information that will improve the state of knowledge and help update implementation of the ERP.

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 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 Record of Decision (ROD), the CALFED Stage 1 evaluation was set for seven years. The subsequent Stage 2 Conservation Strategy was to 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 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 statements 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.

Table 3-1 of the MSCS 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. 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:

> 1) 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.
>
> 2) 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.
>
> 3) Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.
>
> 4) 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.

5) 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.

6) 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.

Please refer to Appendix A for a complete listing of associated Objectives contained within the Strategic Plan.

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). Some of the 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.

Relationship of ERP Conservation Strategy to Other Planning Efforts in the Delta and Suisun Marsh

CALFED planning efforts, including the ERP and its related planning documents, were initially 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's success, failures or budget constraints. In keeping with the dynamic nature of the program, and mandates to manage the ERP adaptively, more current information will be incorporated into planning for the Stage 2 Conservation Strategy. 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. It is a strategic planning document and is non-regulatory in nature.

Several concurrent planning efforts, such as the forthcoming NMFS and USFWS recovery plans for federally listed Delta 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. Recent planning efforts in the Delta and Suisun Planning Area that can supplement existing information include the following:

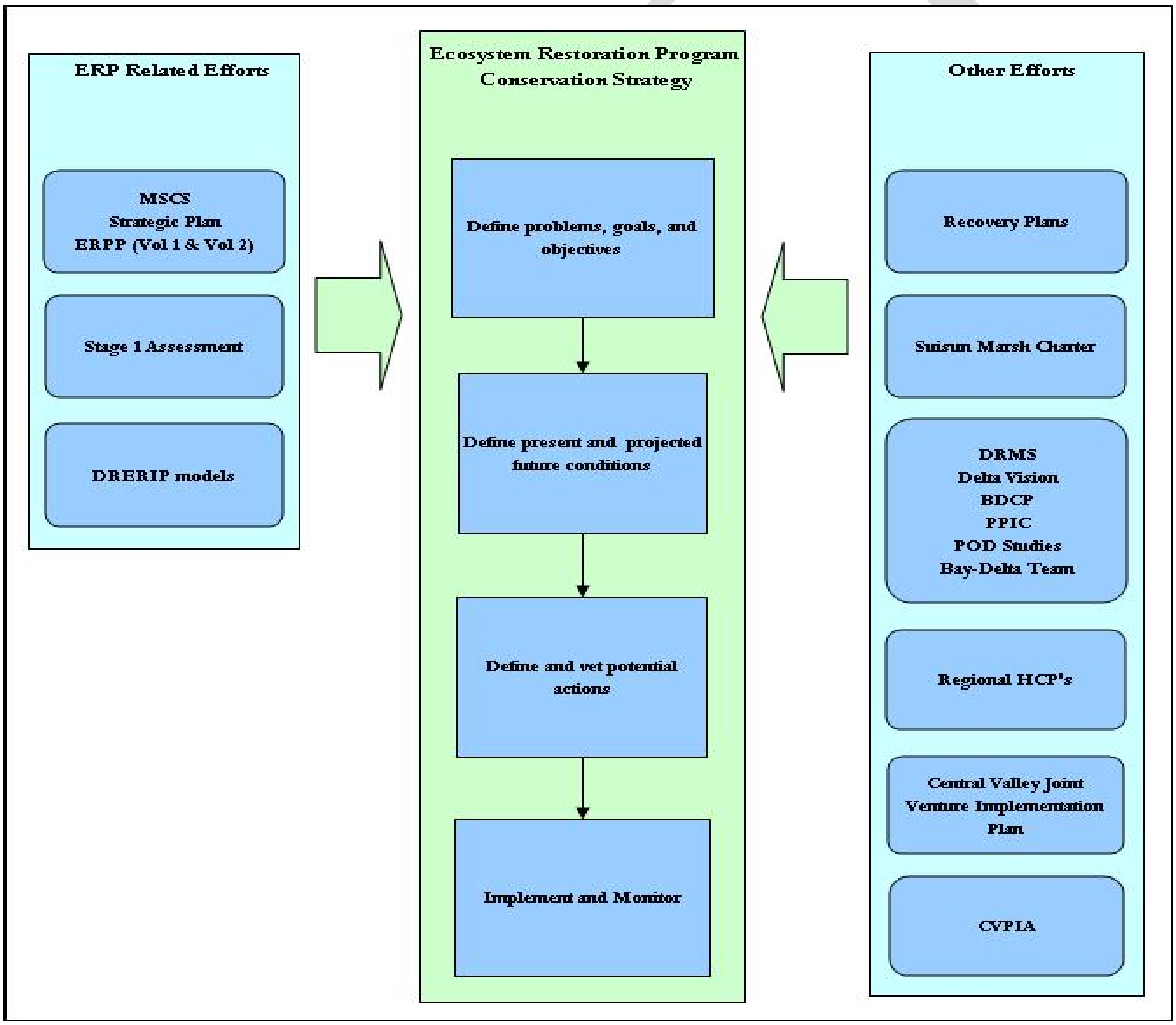


Figure 2. Relationship of ERP Conservation Strategy to other planning efforts

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 devastating environmental and economic consequences.

Several working groups are contributing to the development of the Delta Vision. A Stakeholder Coordination Group provides the Task Force with the diverse Delta stakeholders' perspectives, and issues recommendations on areas for habitat restoration in the Delta. Another group, the Delta Vision Committee, provides perspectives from State agencies and commissions. Delta Vision Committee participants include the Secretaries for Resources, Business Transportation and Housing, Food and Agriculture, CA Environmental Protection Agency, and Public Utilities Commission. The Task Force's 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

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 the Department of Water Resources (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. 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 Bay-Delta Conservation Plan is an applicant-driven process through which certain activities (e.g., water export operations of the State Water Project and Central Valley Project in the south Delta and power plant operations of Mirant Energy in the Pittsburg/Antioch area) would comply with FESA and CESA, with appropriate assurances. 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. 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. 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 by the end of 2009 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) Report

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.

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 protect and enhance Suisun Marsh's contributions to the vital Pacific Flyway plus existing wildlife and endangered species habitats, maintain and improve strategic exterior levees, 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 spring 2008 (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 recovery plan. 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 completing 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 CVJV 2006 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. The knowledge and experience of CVJV and its member entities would be a significant asset in the implementation of such actions in the future.

Nearby 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 Corps 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.

Conservation Principles Guiding Development of the ERP Conservation Strategy for Stage 2

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 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. These principles may not guarantee the long-term survival of any particular species or ecological service; they offer the best chance of maintaining a high proportion of desirable services into the foreseeable future.

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 of a Robust Conservation Strategy

The ERP Implementing Agencies believe that a robust conservation strategy should include the following fundamental components:

1) Explicit 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.

2) All factors influencing conservation goals; such as for species populations, habitats, and ecological processes; should be identified, if not addressed, within the strategy.

3) The best available science.

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

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

6) Tracking of performance over time (monitoring and performance measures).

7) Adaptability as new information and understanding arises. Often, this is captured within an Adaptive Management approach.

8) Consideration of potential unforeseen or catastrophic (unpredictable) events, and sufficient flexibility to remain viable.

9) Clear identification of areas of uncertainty, with quantification, where possible.

10) Criteria for prioritizing actions; i.e., how will the strategy actions be selected for implementation?

As a work in progress, this document has incorporated each of these components to the extent practicable, and will continue to further develop those that are lacking in detail or are otherwise incomplete. 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 and a prioritization scheme. 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

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.

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. 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 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 agencies 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.

Description of the Planning Area

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.

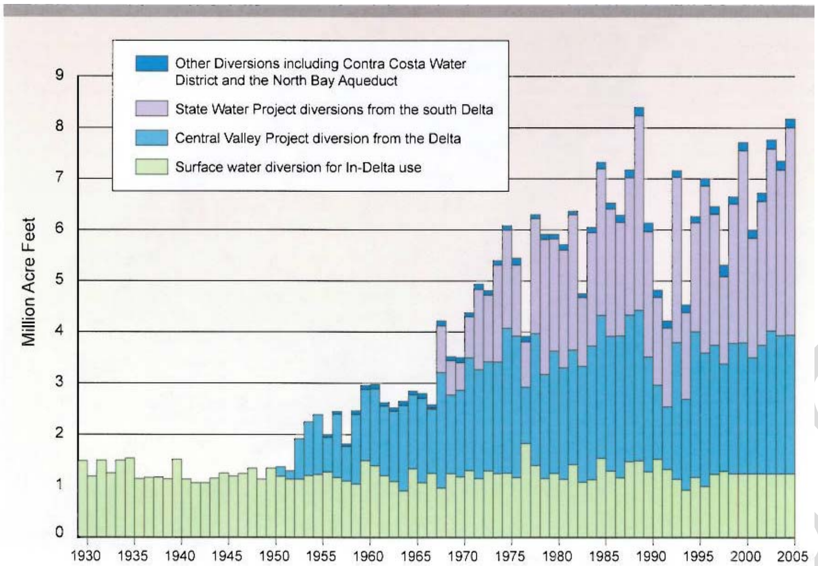
Important aquatic habitats are severely limited by levees and flood control systems. Existing aquatic habitats in the Delta include shaded riverine aquatic (SRA) habitat, vegetated and non-vegetated shallow shoal areas, open-ended sloughs, and small dead-end sloughs. The large, open river channels of 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 habitat are fragmented and subject to excessive erosion from wind- and boat-generated waves. Shallow shoal 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.

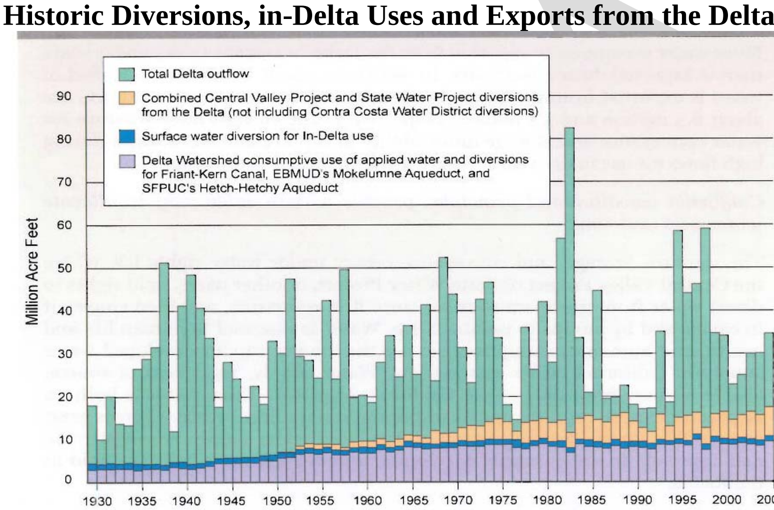
Figure 3

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.

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

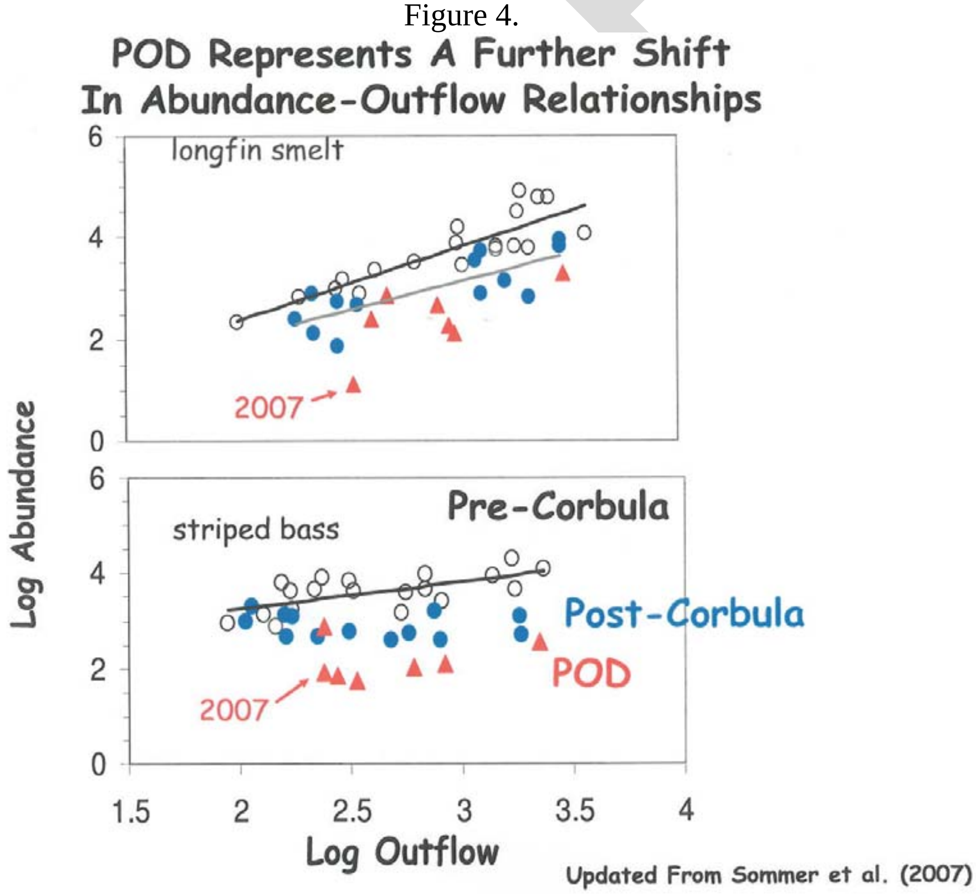
Hydrology

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 4.



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

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.

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.

Salinity. 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, and more information on turbidity as a benefit or a stressor to individual species will be included in future iterations of this document.

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 outproduce 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).

Habitats

Development of the ERP Conservation Strategy Map

The proposed ERP conservation strategy map 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. Future versions of the map will incorporate information from LiDAR data, historical conditions, soils maps, climate change predictions, infrastructure and development, and water conveyance, to better define areas where restoration activities should be focused. DRERIP conceptual models will help guide map refinements. For purposes of this strategy, five broad land categories have been identified for restoration. These categories include intertidal, floodplain, uplands, grassland/vernal pool transition corridor, and subsided lands.

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 was driven by historical conditions and land elevations with consideration of potential sea level rise and other effects of future climate change. Map elevations were presented in 5-foot increments. One major assumption was that lands that are -5 to 0 feet and 0 to 5 feet in elevation offer the best opportunities for restoration of tidal marsh. Land above 5 feet was considered to be conducive to restoration of upland habitats. Lands below -5 feet were considered deeply subsided and not conducive to sustainable restoration of habitat for native aquatic species, although they could provide benefits to some terrestrial species, waterfowl, and migratory birds.

Following are descriptions of current issues and conditions as they relate to the five broad land-based habitat restoration categories that have been identified, as well as rationales for why the various habitat types contained within these categories 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 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.

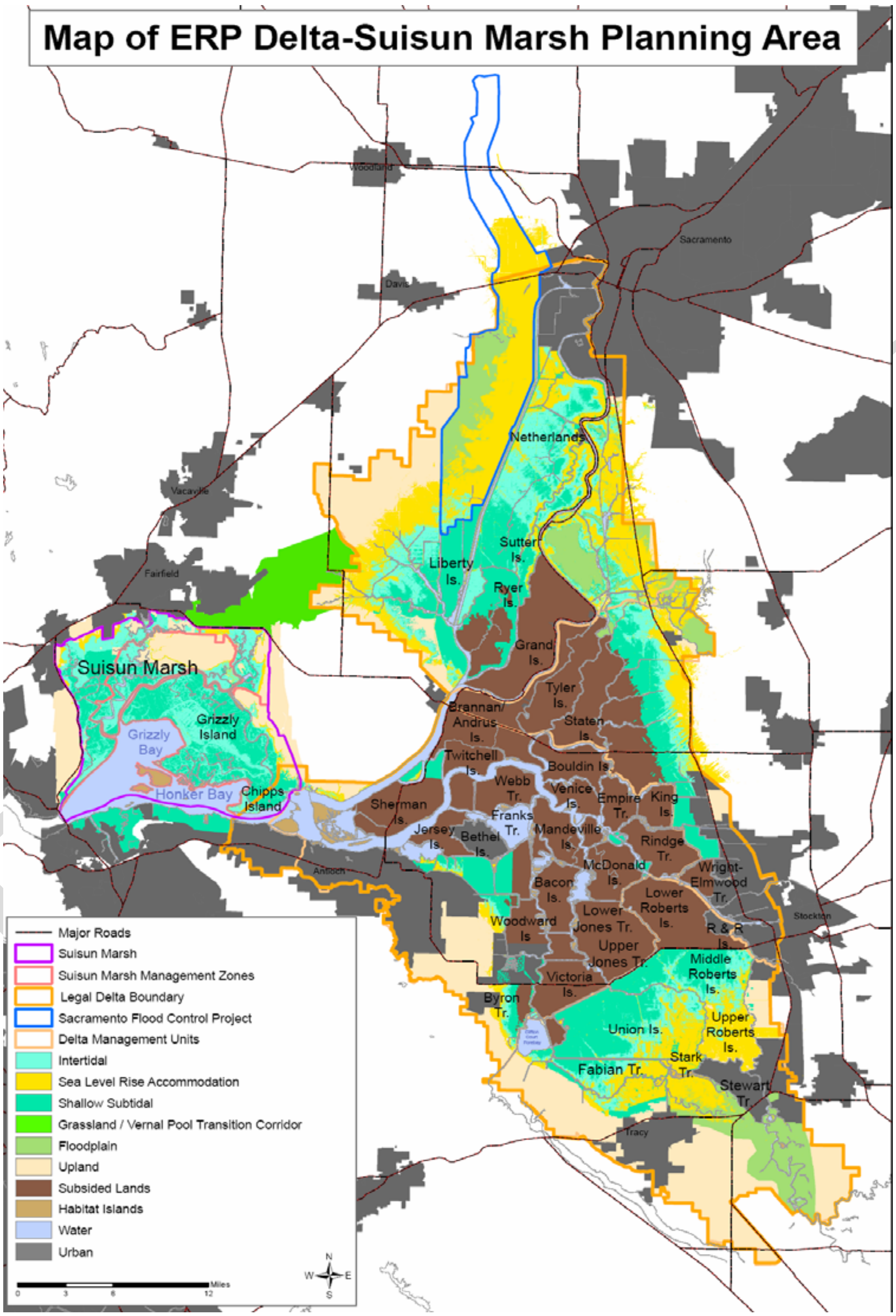


Figure 5. Preliminary map of Delta and Suisun Marsh Planning Area, showing potential suitability for protection, restoration, and management of habitat categories

Intertidal Habitats

Preliminary designation of intertidal is composed of lands that occur between -5 and +5 feet in elevation. More precise information on tidal range will be obtained when the forthcoming LiDAR data become available. 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 still contains about 50,000 acres of marsh habitat, but most has been converted to managed marsh for waterfowl hunting.

In 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 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.

Relatively little study of tidal marsh in the Delta has occurred. That which has occurred (most notably the BREACH studies; http://depts.washington.edu/calfed/breachii.htm), has 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 NH_4 into the Delta from agricultural fertilizer runoff, livestock operations, and municipal sewage outflows. NH_4 inhibits phytoplankton blooms in Suisun Bay (and possibly other open water habitats in the Delta) and 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 in Belgium, tidal freshwater marsh has the ability to transform or retain up to 40% of NH_4 entering the marsh during a single flood tide (Gribsholt et al. 2005). 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 acquired and 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). On Liberty Island 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, starry flounder and others. 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 submerged aquatic vegetation (SAV), however, has made them 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). SAV in the Delta has thrived in the management of the Delta as a homogenous freshwater system. 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.

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 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.

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)

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. 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 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. 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.

Finally, floodplain areas can 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 (easement title) 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 management 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 (these shallow areas also provide 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].

Upland Habitats

The area identified as the upland category is best characterized as land well above current sea level (>5 feet in elevation). Habitats compatible with this category include nontidal perennial aquatic, seasonal wetland, perennial grassland, riparian and 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 the richness of diversity of species, ecological processes and species adaptations, and ecological connections that are in some cases unique to the specific habitat types found within this broad habitat classification (such as vernal pools). Vernal pools provide essential habitat that is critical to the continued existence of local populations of amphibian, fairy shrimp, and invertebrate species that have adapted to the wetting and drying cycles of vernal pool and seasonal wetland areas (Green Futures date unk.). Perennial grasslands support vernal pool habitats and processes, by controlling the spread of invasive and/or non-native plants through grazing management; the grasslands themselves also provide habitat for a number of reptile and amphibian species (World Wildlife Fund 2001). 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 these different habitat types, and enhancing the connectivity between them, will be important for helping to maintain genetic diversity of the numerous terrestrial species (some of which also serve as a food source for fish species) that utilize these upland areas for all or parts of their life cycles. Other terrestrial and aquatic species in the planning area could also benefit from the nutrient exchange of the land-water interface in these upland areas, once the nutrients have been mobilized to aquatic areas downstream.

With increasing sea level, global warming, and regional climate change, Delta and Suisun Planning Area habitats and species are going to require space to respond to these changes. As sea level rises, habitats within the Planning Area are expected to shift inland. The difference in elevation between the upland areas and sea level would decrease as sea level rises, making these upland areas more amenable for transition into intertidal habitats. 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 and making extreme winter runoff events more frequent and intense; thus, some of these upland areas would also be expected to accommodate additional flood flows in new and/or expanded floodplain areas.

Grassland/Vernal Pool Transition Corridor

Although located outside of the legal boundaries of the Delta and Suisun Marsh and Bay, the unique habitat category of grassland/vernal pool transition corridor is identified primarily to provide connectivity between the habitat restoration anticipated for the North Delta and Suisun Marsh and the adjacent upland habitats. This habitat category includes opportunities for restoration of seasonal wetlands (e.g., vernal pools), riparian and riverine aquatic habitats, and perennial grassland habitats, with the same ecological benefits as noted above for Upland habitats.

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. For the purpose of this draft of the conservation strategy and the focus on pelagic organisms, this category is intended to highlight the fact that restoration actions in the deep Delta are extremely limited or non-existent in a sustainable manner for benefits to endangered native fish species. Given the 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 Delta Risk Management Strategy and 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. However, the 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. However, due to elevation, levee sustainability, and risk of catastrophic events, this area is low priority for restoring native aquatic habitats.

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 for terrestrial species 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.

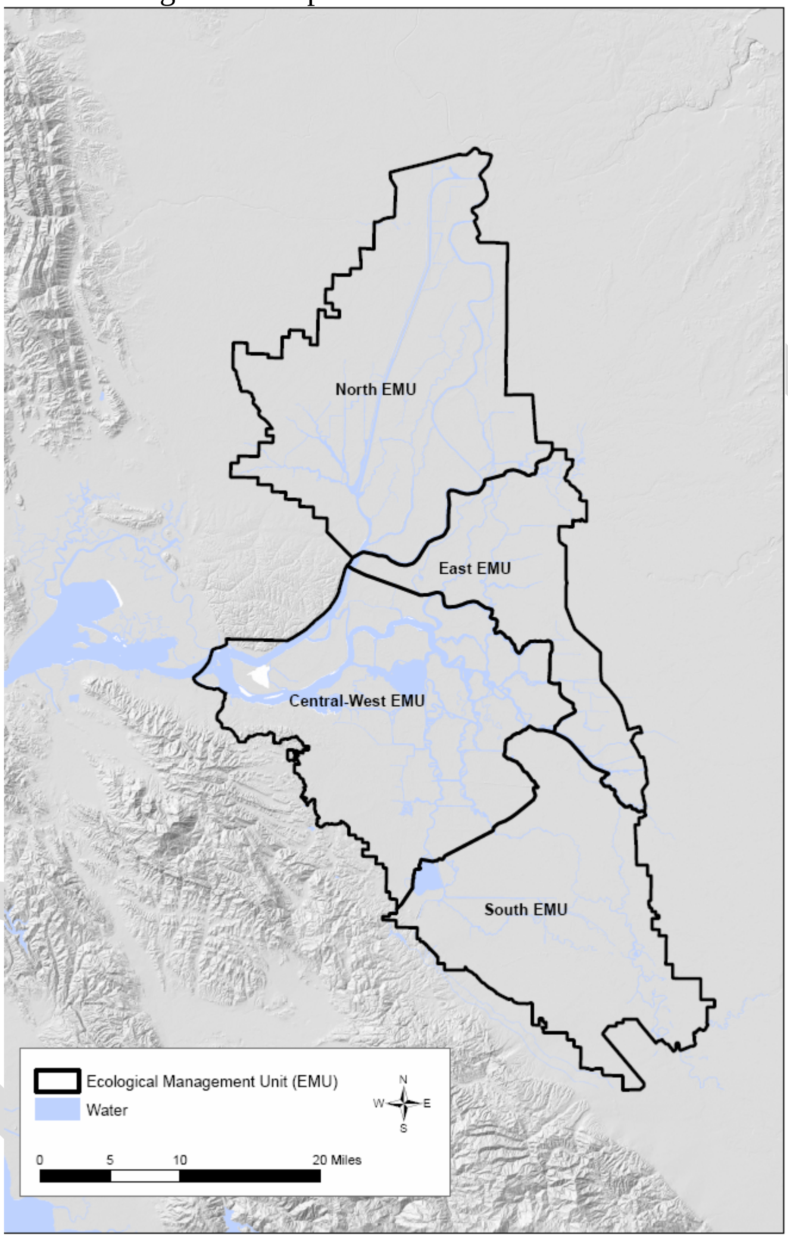
US Geological Survey is interested in implementing a subsidence reversal program Delta-wide, after further assessing the results of their pilot study on Twitchell Island. Such a program would involve offering financial incentives to farmers to create and manage wetland areas on their lands (Fujii 2007). While the primary objectives of creating these wetland areas 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).

Restoration Opportunities in the Planning Area

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

North Delta EMU. 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. ERP is continuing its efforts to 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 ship channel and the Sacramento River, including Miner, Steamboat, Oxford, and Elk sloughs, should be improved 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. 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

Figure 6. Map of Delta EMZ and EMUs



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 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. Restoration opportunities in the CSC include improving our understanding of the processes taking place on the breached and naturally restoring portion of northern Liberty Island and open water areas of lower Liberty Island and Little Holland Tract, and restoring Prospect Island and the eastern edge of Egbert Tract which is part of the 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, and important habitat for delta smelt. Specific goals for the CSC include: (1) Fund 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, such as Liberty Farms; (4) Act to preserve and enhance high-value habitat on Little Holland Tract and tidally active portions of Liberty Island; and (5) Protect vegetation and habitat in the freshwater sloughs in the area including Lindsey, Barker, and Cache Slough and 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 man-made entrainment on 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 CALFED 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 5-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 reliability and reducing maintenance. Expansion of existing shallow water multi-species 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.

East Delta EMU. Activities in the East Delta EMU would consist 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, the Cosumnes River, and the North Fork of the 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.

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 become the new levee along Bouldin Island and the land to the north could be the future site of dredge disposal or subsidence reversal projects to reach desired elevations and then restored to intertidal habitat.

South Delta EMU. ERP activities in the South Delta EMU during Stage 1 have mainly been limited to research projects, several of which are focused on the dissolved oxygen problem in the lower San Joaquin River west of Stockton. Future implementation of the ERP in the South Delta will focus on restoration of ecological processes and habitats.

A new feature proposed for the South Delta EMU is a bypass floodplain 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. 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 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 heavily influenced by the method of 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 global warming. 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 and 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 and 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. For the most part, proposed restoration actions for the Suisun Bay and Marsh are based on the Suisun Marsh Plan being prepared by the Suisun Marsh Implementation Charter agencies. This vision 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. This is a Programmatic NEPA/CEQA process.

Scoping processes for the draft Suisun Marsh Plan have identified six preliminary goals for managing the Marsh. These goals are: (1) Rehabilitate natural processes wherever feasible in the marshes terrestrial, 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, the 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 refuge site for animals during extreme high tide events. Areas currently being restored to tidal are the Blacklock, Hill Slough, Montezuma, Mastelotto, Murphy, West Navy, San Souci, Peytonia Slough, Taylor, and Ryer properties.

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. Flows into the northwestern marsh will be improved.

Improving marsh and slough habitats will benefit Chinook salmon, striped bass, 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 estuary 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 areas such as the Jepson Prairie Preserve in the Yolo Basin Ecological Management Zone (Transition Corridor).

Estimates of Restoration Potential and Needs

The ERP has estimated potentially suitable restoration acreage by ERP Management Zone (Table 1). These acreage estimates are based on GIS analysis of land elevations, but do not fully account for constraints such as infrastructure or flood control. It must also be recognized that most of the land within the Delta is privately owned, and arrangements with land owners would be necessary before habitat restoration could take place.

In addition to estimates of potentially suitable restoration areas, preliminary estimates of habitat area that may be needed for restoration also have been identified (Table 1). Given that remaining available habitat in the Delta is a small fraction of that which once supported Delta species, and that populations of some species are extremely low, these preliminary estimates should be considered the minimum habitat amounts for planning considerations at this early stage in the planning process. The preliminary estimates are represented by ranges of acreage that are somewhat less than the potential suitable restoration acreage, but are considered to be appropriate for restoration planning at this time. For example, a large area of contiguous tidal marsh habitat is required in order to accommodate high-order marsh channels, which are important features for fish (Coats et al. 1995).

The preliminary estimates will be subject to change after consideration of constraints such as future conveyance facilities, infrastructure, land use, information on tidal range, and ability to acquire land (e.g., willing sellers) (see Appendix E). Further refinements should be expected after conducting analysis of relationships among habitat structure, ecological processes, and species needs, and effectiveness of potential restoration actions (i.e., evaluating actions with conceptual models). Additional refinements may result from consideration of historical information, LiDAR-based bathymetric data, and future updates in sea level rise projections. Lastly, consideration must be given to objectives of ongoing species recovery planning and development of population viability analysis.

With respect to implementing habitat enhancement projects, it is anticipated that intertidal and floodplain restoration will involve land acquisition in fee title from willing sellers. For restoration of other habitat types (i.e. uplands and subsided lands), it may be more cost-effective to pursue acquisition of easement interest in properties, although fee title acquisitions from willing sellers may also be pursued.

Table 1. Preliminary estimates of potentially suitable habitat restoration area and restoration area that may be needed in the Delta and Suisun Planning Area.

Management Zone	Intertidal Restoration (acres)		Floodplain Restoration (acres)		Upland Restoration (acres)	
	Potentially Suitable	**Potential Need[1]**	**Potentially Suitable**	**Potential Need[1]**	**Potentially Suitable**	**Potential Need[1, 2]**
North Delta			31,800	7,000-15,000	38,100	10,000-15,000
Cache Slough Complex[3]	39,500	10,000-20,000				
Other Areas[4]	46,900	10,000-15,000				
Yolo Bypass (in Delta)			31,500	7,000-15,000		
Yolo Bypass (outside Delta)			17,000	4,000-7,000		
East Delta	16,800	3,000-7,000			12,300	5,000-10,000
Cosumnes/ Mokelumne			6,500	2,000-4,000		
Outside Delta			8,900	2,000-5,000		
South Delta	52,800	10,000-25,000	27,600	7,000-10,000	55,600	5,000-10,000
Central/West Delta	7,900	3,000-5,000			19,700	1,000-2,000
Suisun Marsh	53,000	6,000-9,000[5]			19,600	3,000-5,000

[1]To be restored by 2030. Half of this acreage would be projected for restoration by 2020.
[2]Additional upland habitat protection will be needed outside the planning area to buffer habitats on the periphery.
[3] Cache Slough Complex defined as low-lying areas west of Sacramento Deep Water Ship Channel, plus Prospect Island.
[4]"Other Areas" refers to lands in the North Delta EMU, outside of the Cache Slough Complex, whose elevations lend themselves to restoration of intertidal habitats; specifically, portions of Ryer and Sutter Islands and Netherlands Tract.
[5]Amount of intertidal restoration called for in Suisun Marsh Plan, Alternative C.

Reductions to 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 Area. The ERP identifies several species 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). 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 under three sections of the DFG 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 to 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. Therefore fish screens on small diversions were not widely pursued in the Delta and Suisun Planning Area during Stage 1 of ERP implementation, largely due to high costs and potentially small population benefits to fish species. Funding for screening small diversions in the Delta is not likely to be a high priority for ERP implementation in Stage 2, but may be pursued in the context of other Delta planning processes.

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 the quantity, quality, and extent of the various habitat types within the planning area that are dependent upon natural flow patterns, in part due to higher water velocities and reduced residence time of water in Delta channels. 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). More information on the negative impacts to species associated with altered hydrodynamics and food web production are included in the section titled "Ecological Processes".

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 diversions during Stage 1, but 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; very little money was expended on this particular stressor in the Planning Area during Stage 1. 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 workshops in 2007. A Core Workgroup has been designed with members from DWR, CDFG, USFWS, NOAA, BOR, Regional and State WQCB, Army COE, EPA, and Academia. CDFG has volunteered to be the "lead agency" performing the various logistic and coordination functions for the group. These discussions are expected to inform development of 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, monitoring and CESA/ESA listing impacts.

Non-native Invasive Aquatic Species

California 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 (see Appendix E of Draft CAISMP). 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.

Non-native invasive species 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. Non-native invasive species 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 localized (i.e. restoration site-specific) implementation in the short term.

Aquatic invertebrates

- *Corbula*

Corbula amurensis, or “overbite” clam, 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*.

- *Corbicula*

Corbicula fluminea, or Asian clam, 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 the 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 also is linked to a greatly diminished phytoplankton biomass. For example, rotifer abundance in western Lake Erie declined by 74% between 1988 and the 1989-1993 period, 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, if these species become established in the estuary in the future.

- *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 negative 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 and slumping and, over time, may pose a serious threat to Delta levee integrity. The crabs also interfere with bay shrimp fishing by fouling nets.

- *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. 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 primarily as a result of the declining trophic status of the Bay- Delta. Its population decline was also affected by competition with *Acanthomysis aspera*, an introduced mysid shrimp of somewhat smaller size but similar feeding habits.

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*, hydrilla, 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, harm fish and wildlife, reduce foodweb productivity, reduce turbidity, or interfere with water conveyance and flood control systems. SAV has been implicated in the reduction in native ichthyoplankton and adult fish in areas with large amounts of SAV (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. In FY 2006/2007, the Department of Fish and Game received $900,000 from the legislature for weed control projects on DFG lands; this funding could be used to control weeds and SAV at Grizzly Island, Hill Slough, Cache Creek, and Yolo Basin Wildlife Area (Horenstein, pers. comm.). In the short term, it would also be ideal to focus SAV control activities on specific habitat restoration sites (e.g. Liberty, Decker, and Kimball Islands), in cooperation with the entities who own those properties.

Water Quality

Contaminants are organic and inorganic chemicals and biological pathogens that can cause adverse physiological response in humans, plants, fish, and 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

The use of pesticides has led to environmental pollution and health hazards, including cases of severe acute and chronic human poisoning (Yamashita et al. 1997, Bradberry et al. 2005). Some of these compounds are not biodegradable and thus accumulate in the environment and tend to be toxic at higher concentrations (Bro-Rasmussen 1996). Also, a low-level long-term exposure to pesticides can lead to cancer and other genetic disorders (Zahm and Blair 1992). 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 great concern because of their potential toxicity to species in the planning area. Pesticide use has changed since Stage 1 began in 2000; initially, organophosphate (OP) pesticides such as diazinon and chlorpyrifos were widely used. However, as OP toxicity received increasing attention from CVRWQCB and other regulatory agencies, the use of OP pesticides decreased in favor of increasing 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 and because detection levels for pyrethroids are at or higher than toxic levels. 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 results 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). Lab studies of salmon with sublethal exposures to pyrethroids showed significant increased susceptibility to mortality from disease (DFG 2008b). These chemicals and other 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 and its upstream tributaries. 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). Increased efforts to enforce current discharge requirements would help to identify sources of pollutants and reduce pollution loadings. 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 (and life stages) that may be affected. The ERP implementing agencies plan to 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, see notes). 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) of 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 (diatoms grow faster on nitrate than on ammonium) (Swanson and Kimmerer 2008, see notes). 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).

It is important to note that, in general, chemical contaminants in water bodies are regulated to an extent by Regional Water Quality Control Boards, through monitoring of point sources included in NPDES permits and through the development of contaminant-specific TMDLs. It is recognized that the presence of multiple contaminants in water bodies may cause synergistic toxic effects to aquatic species, depending upon the species and chemical interactions at play. These potentially synergistic interactions of chemicals under varying environmental conditions (pH, nutrients, temperature) can be extremely difficult to analyze; thus NPDES permits and TMDLs for individual contaminants may not be adequately protective of species health. The synergistic toxic effects of chemical contaminants on individuals and populations should be an area of targeted research in the future.

Low 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 level 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: loads of oxygen-demanding substances from upstream sources that react by numerous chemical, biological, and physical mechanisms to remove DO from the water column; DWSC geometry impacts that add or remove DO from the water column, resulting in increased net oxygen demand; and 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).

As noted above, ERP implementing agencies plan to 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. The Regional Boards have assembled extensive data on the DO problem through its Total Maximum Daily Load (TMDL) process.

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 the higher methylmercury habitats have extended dry periods in which soil and sediment completely dry out, which raises the possibility that oxidation of mercury species 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 species during dry periods may also play an important role in increasing mercury methylation rates during subsequent flooding. [Alpers 2007] Studies are ongoing at the Yolo Basin Wildlife Area that include development of BMPs to manage any 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]

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] 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 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).

Selenium

Irrigation of agricultural lands and water management practices have resulted in toxic levels of selenium, a metal that occurs naturally in the environment (CVRWQCB 2007). 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, see notes).

Any change in Delta infrastructure and conveyance will result in changes to transport routes, source mixtures, and flushing times of water and contaminants within the Delta (Monsen et al. 2007). With new facilities conveying fresh Sacramento River water around the Delta, there is the potential for selenium bioaccumulation to increase 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. As is the case with mercury methylation, activities that may result in increased selenium bioaccumulation must be weighed against the negative impacts associated with not restoring more natural hydrologic conditions to help recover species.

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).

List of Species to Benefit from Restoration Actions in the Planning Area

The Delta and Suisun Marsh support many species of native and nonnative fish, waterfowl, shorebirds, and wildlife. The ERP 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 3).

Table 2. 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

Future Conditions ("Drivers of Change") and Ecosystem Response

There are a number of biological, physical, legal, and socioeconomic conditions that may present constraints to program implementation; these are discussed in Appendix E. 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, all 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 are anticipated. Anticipated rapid flooding of subsided islands in the western and central delta would increase intrusion of brackish water into the Delta, resulting in significant changes in distribution, type, and quality of habitat.

- 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 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 inevitable. Restoration activities will need to be monitored and adaptively managed in response to unavoidable impacts on the Delta ecosystem.

- Urbanization and Population Growth. The Delta is surrounded by some of the most rapidly urbanizing areas in California; this 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, particularly with respect to accommodating native species, and it will likely become increasingly difficult for resource managers to balance 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.

Over the longer term, specific actions for implementation would be identified through collaborative workshops where actions would be scientifically developed and/or evaluated utilizing the DRERIP conceptual models and analytical framework. To help ensure buy-in from the interested public and stakeholders which will be critical to the success of this and other adaptively-managed programs in the Delta, these workshops would produce detailed descriptions of the evaluation and decision processes for the various actions. This information would be made available to the public and stakeholders on the Web or upon request. The transparency of these exercises will help ensure that participants understand the evaluation process, get appropriate guidance in formulating additional actions for evaluation, and use the conceptual models correctly. All proposed actions would also be screened for feasibility in terms of the constraints identified earlier in this document.

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 our 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).

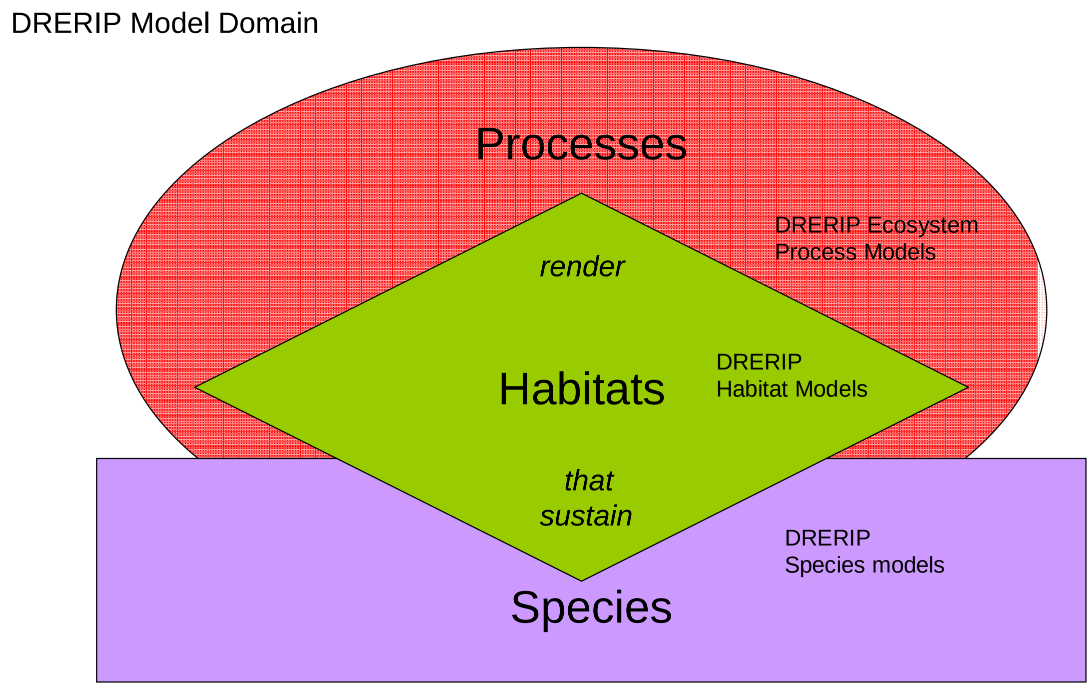


Figure 7. Ecological processes interact to support habitat types, which in turn support species using the habitats.

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.

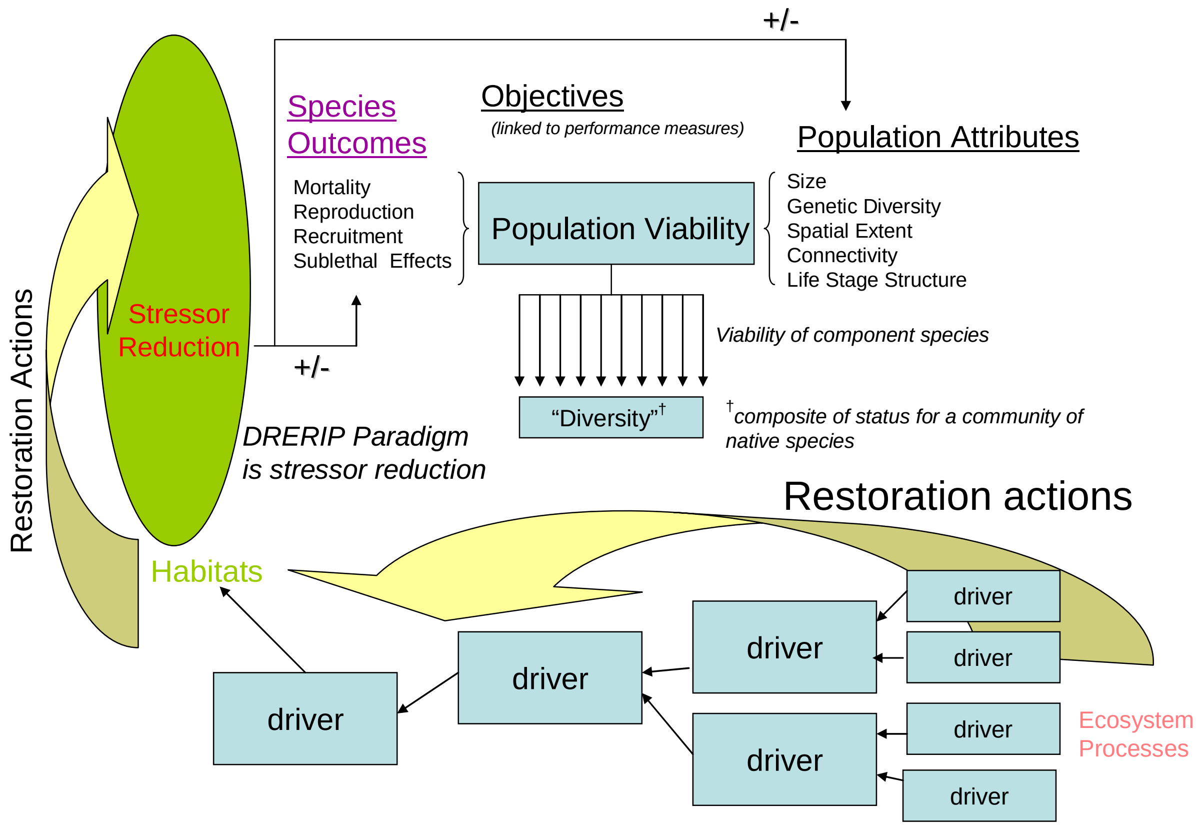
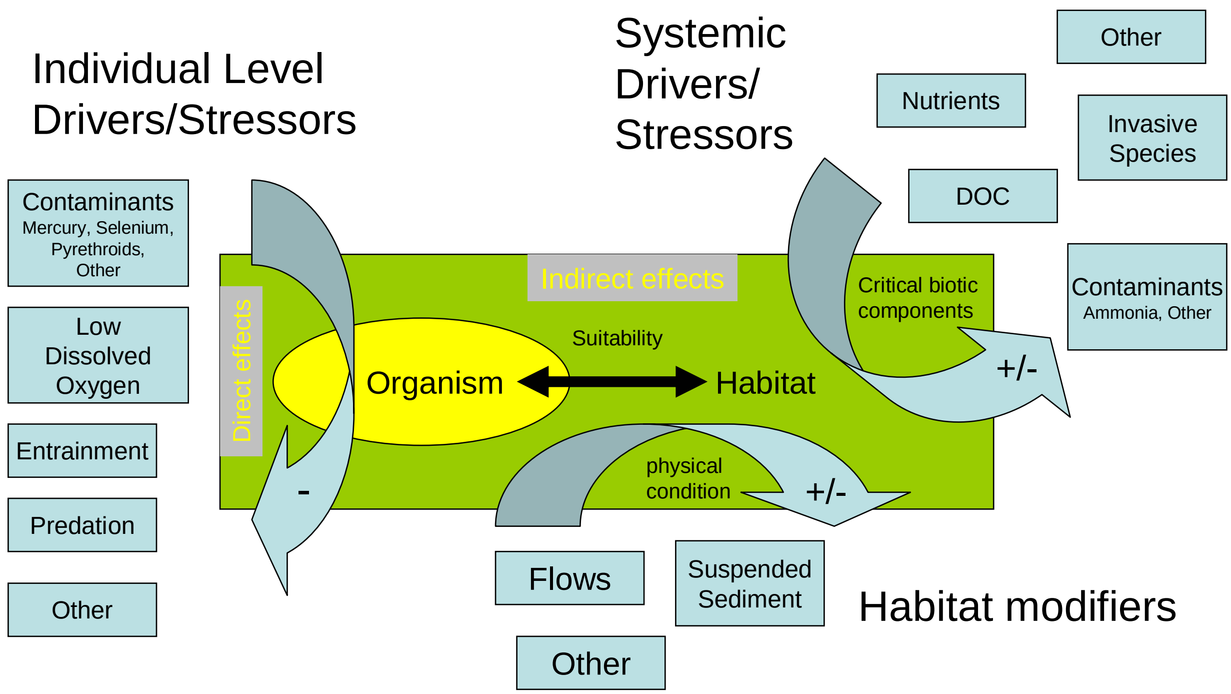


Figure 8. Restoration actions are directed to restore ecosystem processes, reduce stressors, and enhance habitats to achieve desired outcome of enhanced native species population viability and diversity.

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 this Conservation Strategy, as well as strategies developed for other EMZs in the ERP focus 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.).

For wetlands and floodplains, hydrologic criteria will be incorporated to reflect restoration needs of these habitats. These criteria may include frequency, depth, and duration of flooding for floodplain and specific wetland types and management purposes (e.g. managed marsh for duck clubs or natural wetlands and floodplain to mimic pre-settlement conditions). Marsh hydrology criteria from ongoing wetland management programs, such as Suisun Marsh, may be suitable.

As the process for development of the Conservation Strategy for the Delta and Suisun Planning Area advances in coordination with other planning processes occurring in the Delta and Suisun Bay over the next one to two years, there will be specific environmental documentation that will address issues related to third-party impacts, socioeconomic factors, and environmental justice issues in accordance with CEQA and NEPA.

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.

Governance

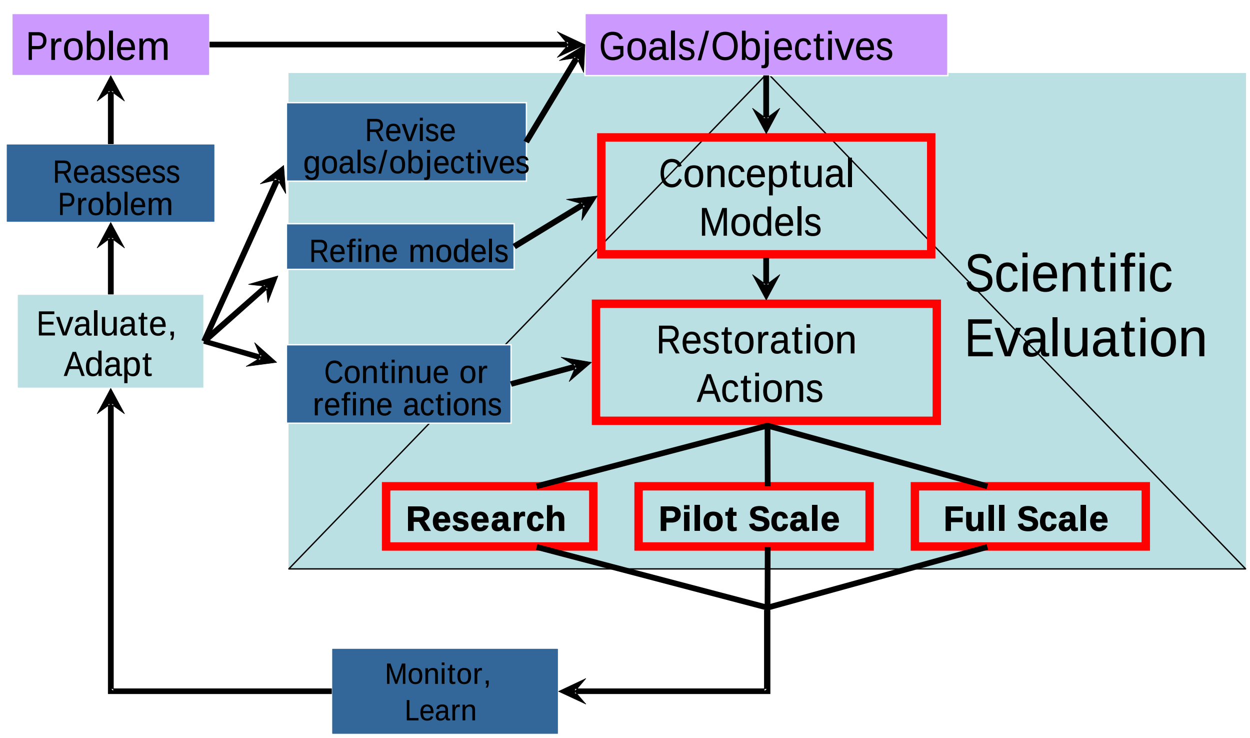
There is recognition that any long-term solution for the Delta to continue to accommodate both ecosystem and economic uses will include the creation of a governance structure that can implement that solution; these governance issues are currently under deliberation by the Delta Vision planning effort 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. .

Monitoring, Adaptive Management, and Performance Measures

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) to 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:

Define indicators and performance measures that meet Program objectives.

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.

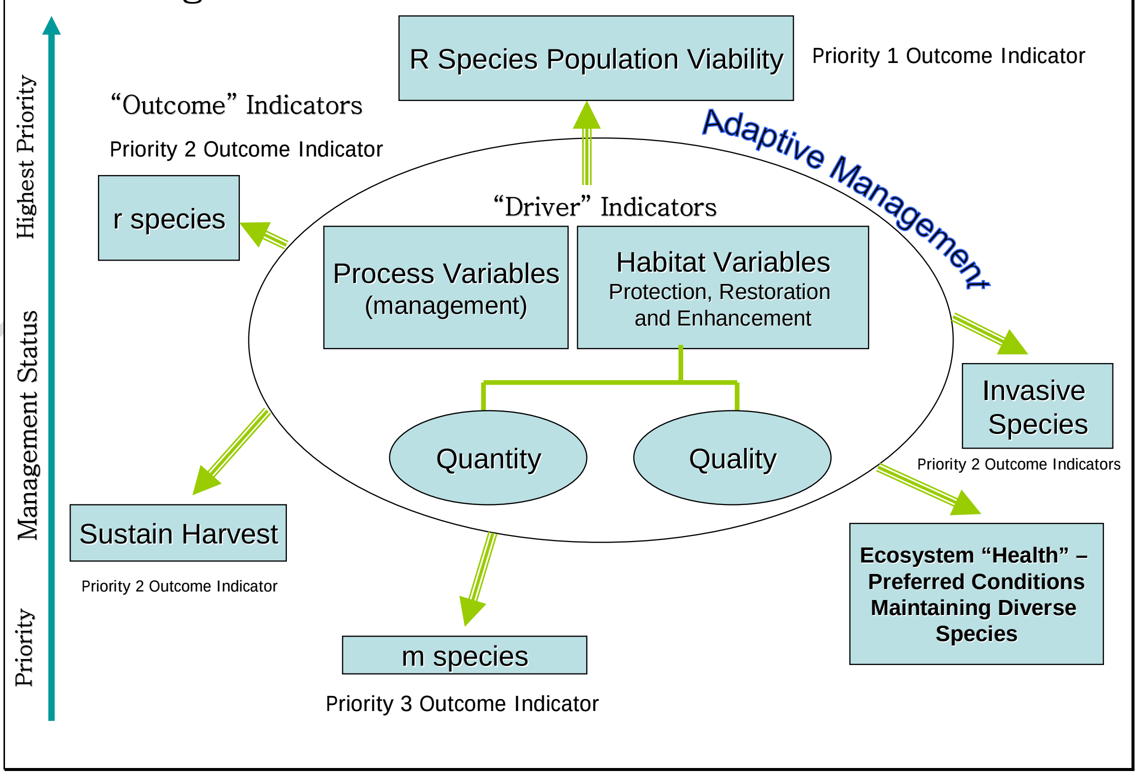
11) Program performance will be evaluated on a regular basis based on performance metrics.

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, 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, and striped bass hatchery, 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 and 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 main rain 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 LIST OF SPECIES AND ASSOCIATED HCP and HCP/NCCP PLANNING AREAS
DELTA PLANNING

	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**
	Cotula Navarretia, *Navarretia cotulifolia*	**X**						**CNPS 4.2**

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	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/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
	Burrowing Owl, *Athene cunicularia*	X	X		X	X	X	CA CSC
	Aleutian Canada Goose, *Branta hutchinsii leucopareia*		X	X				

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	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**
	Yuma Myotis Bat, *Myotis yumanensis*					X		**CA CSC**

	Common Name/Scientific Name	Solano	Natomas Basin	San Joaquin	East Contra Costa	South Sacramento	Yolo	Rarity/Status
	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

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

Potentially suitable habitat restoration acreages in the planning area

Ecological Management Unit (EMU)	**Potentially Suitable for Intertidal (acres)**	**Potentially Suitable for Floodplain (acres)**	**Potentially Suitable for Uplands (acres)**	**Grassland/ Vernal Pool Transition Corridor (acres)**	**Subsided Lands (acres)**
North Delta	82,600	64,300	38,100	200	23,700
East Delta	17,500	6,500	12,300	0	39,600
South Delta	52,800	27,600	55,600	0	13,500
Central/West Delta	7,900	0	19,700	0	103,700
Suisun Marsh*	53,000	n/a	19,600	800	n/a
Outside of Delta & Suisun Marsh Bounds [1]	11,800	26,600	< 1,000	15,000	

* Source: Acreage identified in Suisun Marsh Plan

[1] There are ecological benefits that can be realized by restoring lands located outside of the legal boundaries of the Delta and Suisun Marsh. Examples include:

- The Grassland/Vernal Pool Transition corridor would establish connectivity between restoration occurring in the North Delta EMU and the Suisun Marsh.
- Levee setbacks on the west side of the Sacramento River south of Rio Vista could accommodate enhanced riparian habitat
- Floodplain restoration areas in the Delta are influenced by flows upstream; therefore, restoration activities may be desirable upstream of boundaries (north to Fremont Weir on the Yolo Bypass in the North Delta EMU, and east of the confluence of the Cosumnes and Mokelumne Rivers in the East Delta EMU)

Appendix E

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.

H*azardous 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 petrochemicals. Buffer width will vary depending on the preserve habitat sensitivity and species needs.

Edge: Most optimal preserve design systems reduce the edge or interface between preserve land and other 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 arise when the floodways are established to protect personal property such as orchards and homes. Liability from placing habitat in a floodway or navigable water in these sensitive areas should be developed so that a no-net-loss of conveyance (velocity or quantity) occurs. 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. Plan Basin plans, conservation areas, floodplain designation, prime agricultural soils designations) Delta Risk Management Strategy Infrastructure and levee stability analysis

Regulatory
Various Farm Bills
1600
Clean Water Act
California Coastal Act
CEQA
NEPA
CESA
FESA
FIFRA
National Historic Preservation Act—They keep digging up middens at Stone Lakes while digging wetlands and get shut down by the local tribe elders.
NPDES
County Regulations: burning, pesticide regulations, grading ordinances, ag preservation regs., 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.

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
Cost of Land
Access-will access easements need to be purchased, and are there overlying financial requirements for road maintenance.
Maintenance of infrastructure-pumps, fences, access roads, levees, firebreaks, drains,
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.
Secure and durable funding
Water - Cost of Water pumping or acquisition of water rights
Taxes
Long-term durable funding stream for mgmt-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
Existing – restoration of habitat-highly degraded 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 structure 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, invasive species and provide high temperatures fire adapted plant species.
Vector Management
Fencing
Buffer areas

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.