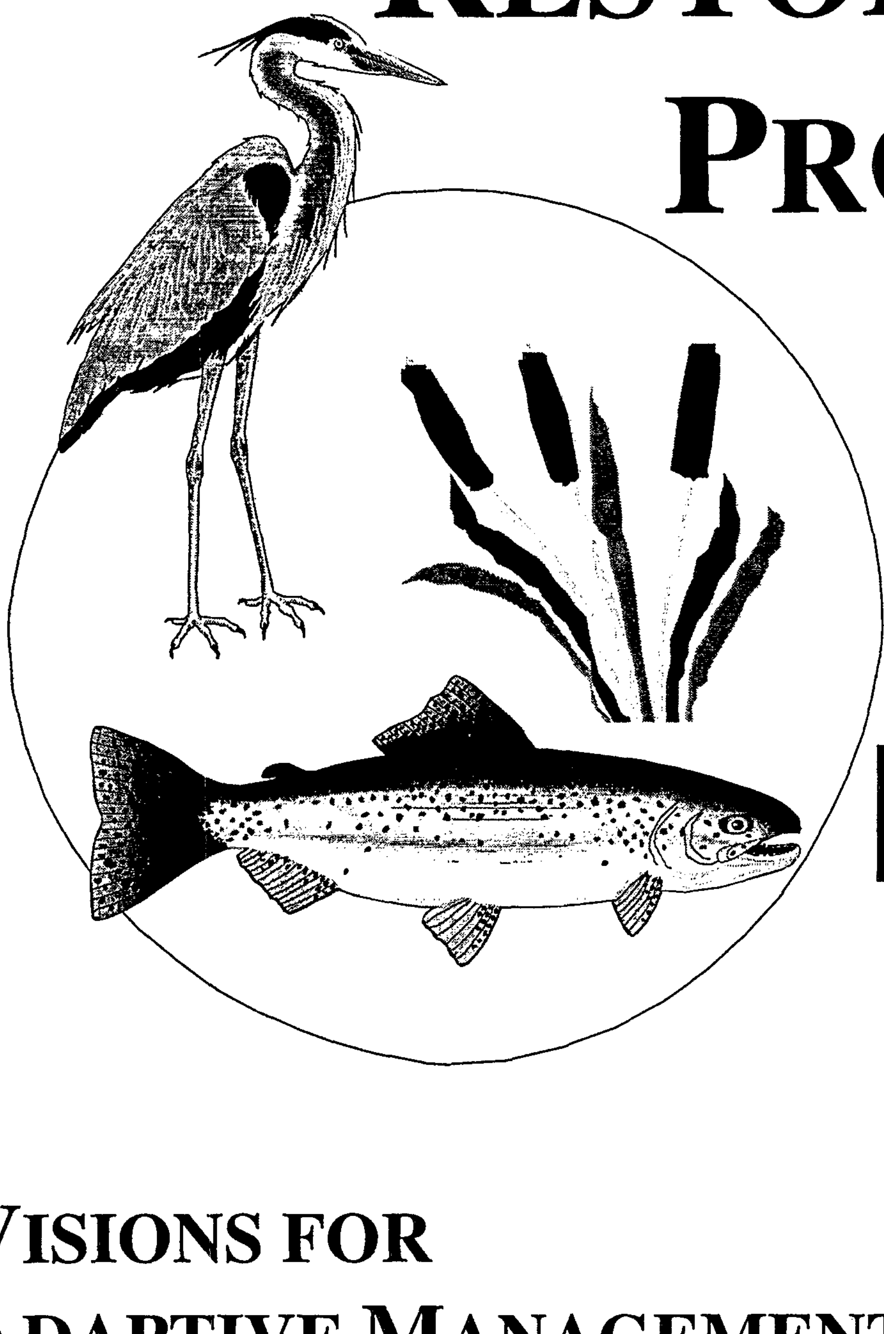
ECOSYSTEM RESTORATION PROGRAM PLAN



VOLUME III

VISIONS FOR ADAPTIVE MANAGEMENT

CALFED
BAY-DELTA
PROGRAM

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CALFED BAY-DELTA PROGRAM
ECOSYSTEM RESTORATION PROGRAM PLAN
VOLUME III: VISIONS FOR ADAPTIVE MANAGEMENT

TABLE OF CONTENTS

CALFED BAY-DELTA PROGRAM
ECOSYSTEM RESTORATION PROGRAM PLAN

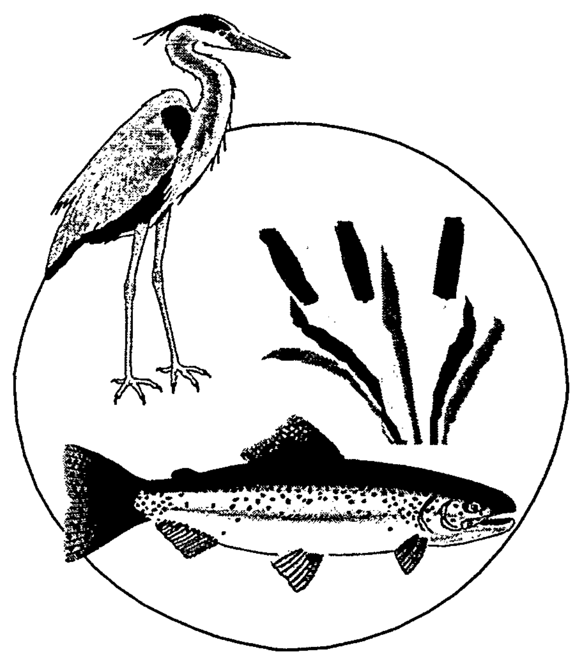
OVERVIEW

The mission of the CALFED Bay-Delta Program is to develop a long-term comprehensive plan that will restore ecosystem health and improve water management for beneficial uses of the Bay-Delta system. The Program addresses problems in four resource areas: ecosystem quality, water quality, levee system integrity, and water supply reliability. Programs to address problems in the four resource areas will be designed and integrated to fulfill the CALFED mission.

The goal for ecosystem quality is to 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. The CALFED Ecosystem Restoration Program Plan (ERPP) addresses this goal. The foundation of the ERPP is restoration of ecological processes that are associated with streamflow, stream channels, watersheds, and floodplains. These processes create and maintain habitats essential to the life history of species dependent on the Delta. In addition, the Program aims to reduce the effects of stressors that inhibit ecological processes, habitats, and species.

The ecological hub of the Central Valley is the Sacramento-San Joaquin Delta and Bay. The ERPP signals a fundamental shift in the way ecological resources of the Central Valley are managed. For many decades, government entities, non-profit organizations, and the private sector have engaged in managing, protecting, regulating, and in some cases breeding fish and wildlife species of the Bay and Delta - yet many populations have not recovered sufficiently and remain in decline. In spite of constant human intervention to repopulate fish and wildlife that have commercial, recreational, and biological importance to society (e.g., hatchery programs and expensive re-engineered water diversions), populations have not been sustained at stable, healthy levels that support historic utilization of those resources.

Historic efforts at individual species regulation and management will be replaced by an integrated systems approach that aims to reverse the fundamental causes of decline in fish and wildlife populations. A systems approach will recognize the natural forces that created historic habitats and use these forces to help regenerate habitats. The Bay-Delta ecosystem is not simply a list of species. Rather, it is a complex living system sustained by innumerable interactions that are physical, climatic, chemical, and biological in nature, both within and outside of the geographic boundaries of the Delta. The central theme of the ERPP is the recognition that truly durable and resilient populations of all fish and wildlife inhabiting the



Bay and Delta require, above all else, the rehabilitation of ecological processes throughout the Central Valley river and estuary systems and watersheds.

The ERPP is fundamentally different from many past efforts in another way as well. It is not designed as mitigation for projects to improve water supply reliability or to bolster the integrity of Delta levees; improving ecological processes and increasing the amount and quality of habitat are co-equal with other program goals related to water supply reliability, water quality, and levee system integrity. Solving serious and long-standing problems in each of these resource areas will require an ambitious, integrated, long-term program.

The ERPP, like all components of Bay-Delta solution alternatives, is being developed and evaluated at a programmatic level. The complex and comprehensive nature of a Bay-Delta solution means that it will necessarily be composed of many different programs, projects, and actions that will be implemented over time. During the current phase of the Program, solution alternatives will be evaluated as sets of programs and projects so that broad benefits and impacts can be identified. In the next phase of the Program, more focused analysis, environmental documentation, and implementation of specific programs and actions will occur.

The CALFED goal for ecosystem quality will be achieved by developing implementation objectives and targets and programmatic actions that can be implemented to restore ecological processes. The restoration of these processes is intended to restore and maintain habitats, and to provide for the needs of the species dependent on a healthy Bay-Delta system. For example, restoring stream channels contributes to sediments, nutrients, and a variety of habitats. The strategy recognizes that not all processes can or should be completely restored and that intervention, manipulation, and management will be required. For example, streambed gravel may have to be introduced, habitats may have to be constructed, and vegetation planted. Still, an important part of the approach is to recommend measures that in the long-term will limit the need for continued human intervention.

Implementation of the ERPP is further guided by the recognition that all landscape units and physical and biological components of the ecosystem are interdependent and dynamic. Interdependence means that actions and stressors in one part of the system can and do affect populations and conditions that may be separated by hundreds of miles (e.g., in watersheds and spawning tributaries), or affect the food web in ways that may not be felt for several years.

Dynamic refers to the exposure of natural systems to constant cycles of change in response to both human and natural factors. Most habitats undergo expansions and contractions, or shifts in space and time. The dynamic nature of healthy habitats is the cause of much biological diversity, and complex habitats tend to make species populations more resilient to change. If the mosaic of habitats distributed across a broad landscape is complex, and if large areas of habitat are connected by smaller patches and corridors such as those associated with riparian systems, then healthy areas of the ecosystem can be relied upon to sustain species during temporary setbacks in other areas.

GEOGRAPHIC SCOPE

The geographic scope of the ERPP is defined by the interdependence and linkage of watersheds, streams, rivers and the Bay-Delta and the complex life histories of the dependent fish, wildlife and plant communities. The restoration of ecological processes requires implementation of actions throughout much of the Central Valley, its upper watersheds, the Bay-Delta, and near-shore ocean. The primary geographic focus is the Bay-Delta, the Sacramento River, the San Joaquin River, and their tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. Secondarily, the ERPP addresses, at a programmatic level, the near-shore ocean and the upper watersheds above the major dams.

The primary geographic focus area for the ERPP can be divided into 14 zones, each characterized by a predominant physical habitat type and species assemblage (Figure 1). These 14 ecological zones constitute the geographic areas in which the majority of restoration actions will occur. The upper watersheds surrounding the primary focus area are important and addressed through general actions that focus on watershed processes.

IMPLEMENTATION STRATEGY

A large and diverse ecosystem like the Bay-Delta is extremely complex. There are many processes and relationships at work in the ecosystem that are not fully understood. Thus, there are many difficulties and uncertainties associated with a program to improve ecosystem health. In some cases, problems are well understood and the steps to improvement are clear. In other cases, there is some understanding of the reasons for decline but this understanding is not sufficient to warrant full-scale implementation of remedial measures. In still other cases, additional research is needed before solutions can be identified with certainty.

The difficulties and uncertainties of ecosystem restoration call for an implementation strategy that is flexible and can accommodate and respond to new information. The foundation of the ERPP implementation strategy is **adaptive management.** Adaptive management is a process of testing alternative ways of meeting objectives, and adapting future management actions according to what is learned. Adaptive management relies upon the identification of indicators of ecosystem health, comprehensive monitoring of indicators to measure improvement over time, focused research, and phasing of actions.

Indicators are features or attributes of the ecosystem that are expected to change over time in response to implementation of the ERPP. Indicators are selected to provide measurable evaluations of important ecological processes, habitats, and species whose status individually and cumulatively provide an assessment of ecological health. Indicators of ecosystem health are the gauges we will used to measure progress toward the goal. Some indicators are very broad in scale while others are very specific. For example, a very broad or landscape level indicator of ecosystem health might be a comparison of the total area of riparian forest to historic coverage or an evaluation of the average distance between patches of such forest with closer patches indicating better health than more distant patches. A more specific indicator might be the concentration of toxic substances in the flesh of adult striped bass.

Comprehensive monitoring is the process of measuring the abundance, distribution, change or status of indicators. For example, contaminant concentrations in fish tissues can be measured at various locations and times in the system to determine if contaminant levels are changing. This will allow progress to be measured, allow actions to be modified if necessary, and provide assurances that the restoration objectives are being achieved.

Focused research will help answer questions about the system and its components and increase the certainty surrounding the relationships of ecological processes, habitats, and species. For example, the relationships among streamflow, storm events, flow-related shaping of river channels to modify habitat, and the physical and chemical signals that flow provides for aquatic species all need to be better understood for effective management of the system..

Phasing is the logical sequence of implementing restoration actions to achieve CALFED goals as effectively as possible. Phasing will consider all targets and programmatic actions and will be used to prioritize actions. For example, actions directed at recovering endangered species and which are consistent with the long-term restoration program and contribute to ecological resilience have a high priority. Early phases of the program will include restoration of ecological processes and habitats that are most important for endangered species recovery, reduction of stressors that affect threatened and endangered species, and other actions that may reduce conflicts between beneficial uses in the system. As restoration progresses and threats to endangered species are reduced or eliminated, restoration efforts can expand and focus on the broader issue of restoring ecological health.

The ERPP will be refined and implemented according to the steps listed below.

1. **Refine** the ERPP based on broad public participation, and using the best scientific knowledge currently available in the short term.

2. **Set the priority** for implementation and funding of ecosystem recovery projects based on a hierarchy designed to ensure the greatest level of ecosystem resilience against future disturbance, and to support self-sustaining populations that require the least amount of human intervention possible.

3. **Conduct immediate focused research** to improve understanding of the ecosystem and the causes of identified problems. Use results from short-term studies to adjust the way that objectives are achieved, making refinements to the final ERPP targets, actions, and implementation schedule.

4. **Develop and begin a phased implementation** program that entails:

    - short-term implementation of ecosystem restoration demonstration projects (e.g., through Category III and related programs), including stressor reduction measures, to help threatened populations begin recovering and to test the viability and effectiveness of targets and actions,

    - coordinated monitoring, evaluation, and reporting of the results of recovery efforts, and the status of ecological indicators in the Bay-Delta and other zones, and

    - adaptive management of each successive phase of ERPP implementation, including pragmatic adjustments to ecosystem targets, funding priorities, and restoration techniques to ensure that public and private resources are well spent and complement other related efforts.

During refinement and implementation of the ERPP, public accountability and program effectiveness will be assured through continuing public involvement as well as environmental impact analysis and documentation.

TERMS USED IN THE ERPP

The following terms are used in the ERPP:

- **ECOSYSTEM ELEMENT:** An ecosystem element is a basic component or function which, when combined with other ecosystem elements, make up an ecosystem. An ecosystem element can be categorized as a process, habitat, species, species community or stressor.

- **ECOLOGICAL PROCESS:** Ecological processes act directly, indirectly, or in combination, to shape and form the ecosystem. These include streamflow, watershed, stream channel, and floodplain processes. Watershed processes are closely linked to streamflow and include fire and erosion. Stream channel processes include stream meander, gravel recruitment and transport, water temperature, and hydraulic conditions. Floodplain processes include overbank flooding and sediment retention and deposition.

- **HABITATS:** Habitats are areas that provide specific conditions necessary to support plant, fish, and wildlife communities. Some important habitats include gravel bars and riffles for salmon spawning beds, winter seasonal floodplains that support juvenile fish and waterbirds, and shallow near-shore aquatic habitat shaded by overhanging tule marsh and riparian forest.

- **SPECIES AND SPECIES GROUPS:** Certain species or groups of species are given particular attention in the ERPP. This focus is based on three criteria that might be met by a species: 1) it is threatened, endangered, or a species of special concern (e.g., delta smelt); 2) it is economically important, supporting a sport or commercial fishery (e.g., striped bass); or 3) it is an important prey species (e.g., Pacific herring).

- **STRESSORS:** Stressors are natural and unnatural events or activities that adversely affect ecosystem processes, habitats, and species. Environmental stressors include water diversions, water contaminants, levee confinement, stream channelization and bank armoring, mining and dredging in streams and estuaries, excessive harvest of fish and wildlife, introduced predator and competitor species, and invasive plants in aquatic and riparian zones. Some major stressors affecting the ecosystem are permanent features on the landscape, such as large dams and reservoirs that block transport of the natural supply of woody debris and sediment in rivers or alter unimpaired flows.

- **VISION:** A vision is what the ERPP will accomplish with the stated objectives, targets, and programmatic actions for an ecological process, habitat, species or species group, stressor, or geographical unit. The vision statements included in the ERPP provide technical background to increase understanding of the ecosystem and its elements. Two types of vision statements are included in the ERPP: visions for ecosystem elements and visions for ecological zone. A resource vision addresses an individual ecological processes, habitat, species or species group, or stressor, while an ecological zone vision addresses the integration of ecological processes, habitats, species, and stressors within a clearly delineated geographical area. Cumulatively, the visions also provide detailed descriptions of the ecosystem and its elements as they will look and function after restoration is accomplished.

- **IMPLEMENTATION OBJECTIVE:** An implementation objective is the most specific and detailed description of what the ERPP strives to maintain or achieve for an ecosystem element. Implementation objectives are not intended to change over the life of the program. For example, the implementation objective for tidal perennial aquatic habitat is to increase the area of shallow-water and intertidal mudflat habitat to improve conditions that support increased primary and secondary productivity; provide rearing and foraging habitat, and escape cover for fish; and provide foraging and resting habitat, and escape cover for water birds.

- **TARGET:** A target is a qualitative or quantitative statement of an implementation objective. Targets are something to strive for but may change over the life of the program with new information and progress, or may vary according to the configuration of storage and conveyance in all alternatives. Targets may include a range of values or a narrative description of the proposed future value of an ecosystem element. Targets are to be set based upon realistic expectations, must be balanced against other resource needs and must be reasonable, affordable, cost effective, and practicably achievable.

The intent of the ERPP is to achieve ecosystem health; targets are flexible tools to guide the effort. The level of implementation for each target will be determined or adjusted through adaptive management. Targets are categorized according to the three levels of certainty described above: (1) targets that have sufficient certainty of success to justify full implementation in accordance with program priorities and phasing; (2) targets which will be implemented in stages with the appropriate monitoring and evaluation to judge benefits and successes; and (3) targets for which additional research, demonstration and evaluations are needed to determine feasibility or ecosystem response.

An example of a target for tidal perennial aquatic habitat is to restore 1,500 acres of shallow-water habitat in the Suisun Bay and Marsh Ecological Unit, and restore 1,000 acres of shallow-water habitat in the San Pablo Bay Unit.

- **PROGRAMMATIC ACTION:** A programmatic action represents a physical, operational, legal, institutional change or alternative means to achieve a target. The number of actions and their level of implementation is subject to adjustment by adaptive management. For example, the number of diversions screened may be adjusted up or down depending on the overall response of fish populations to screening and other restoration actions.

  An example of a programmatic action is to develop a cooperative program to acquire and restore 1,500 acres of shallow-water habitat in the Suisun Bay and Marsh Ecological Zone.

The relationship of ecological processes, habitats, and species is presented in Figure 2..

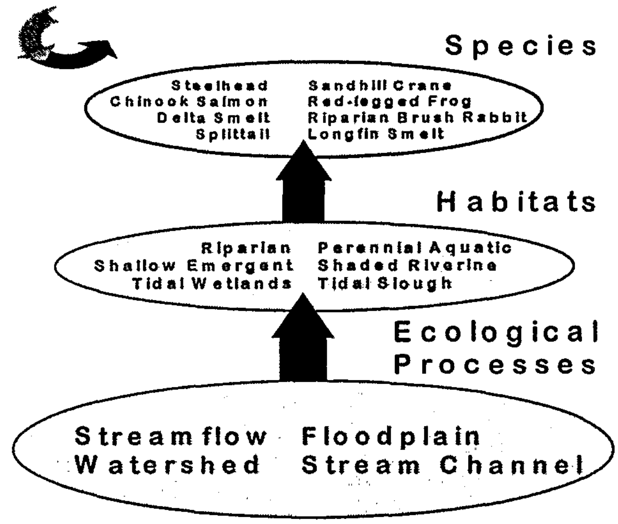


Figure 2. Relationship of ecological, processes, habitats, and species in the Ecosystem Restoration Program Plan.

ORGANIZATION OF THE PLAN

The ERPP is comprised of three volumes:

- **Volume I: Visions for Ecosystem Elements,**
- **Volume II: Visions for Ecological Zones,**
- **Volume III: Visions for Adaptive Management, Indicators, Monitoring, Focused Research, and Phasing of Implementation Actions.**

VOLUME I: VISIONS FOR ECOSYSTEM ELEMENTS presents the visions for ecological processes and functions, fish and wildlife habitats, species, and stressors that impair the health of the processes, habitats, and species. The visions presented in Volume I are the foundation of the ERPP and displays how the many ecosystem elements relate to one another and establishes a basis for actions which are presented in Volume II.

VOLUME II: VISIONS FOR ECOLOGICAL ZONES presents the visions for the 14 ecological zones and their respective ecological units. Each individual ecological zone vision contains a brief description of the ecological zone and units, important ecological functions associated with the zone, important habitats, species which use the habitats, and stressors which impair the functioning or utilization of the processes and habitats. Volume II also contains implementation objectives, targets, and programmatic actions which describe the ERPP approach to improving the ecological health of the zone and its contribution to the health of the Delta. Rationale are also contained in Volume II which clarify, justify, or support the targets and programmatic actions.

VOLUME III: VISIONS FOR ADAPTIVE MANAGEMENT provides the ERPP approach to adaptive management and contains the proposed plans for indicators of ecological health, a monitoring program to acquire and evaluate the data needed regarding indicators, a program of focused research to acquire additional data needed to evaluate program alternatives and options, and the approach to phasing the implementation of the ERPP over time.

INTRODUCTION TO VOLUME III

Volume III (Visions for Adaptive Management) contains information related to indicators of ecological health, monitoring of the identified indicators, focused research to improve our knowledge of the ecosystem and improve management and restoration, and a plan for the development of a logically phased implementation program. The visions for adaptive management and its components establish the foundation by which to improve the scientific basis of the ERPP, respond and adjust the program to new information, and gauge progress toward meeting the implementation objectives.

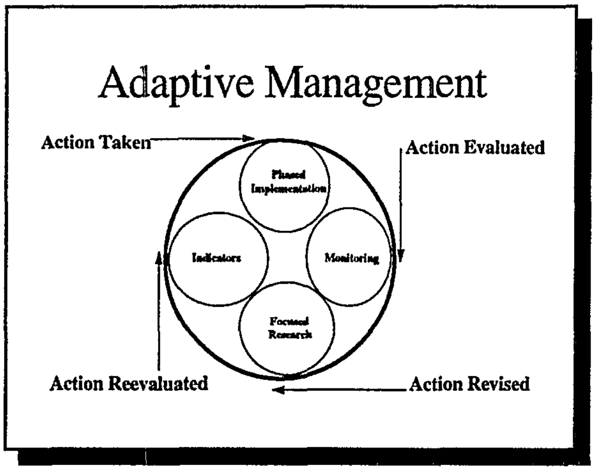
Volume IIII is divided into five sections: (1) vision for adaptive (2) vision for indicators, (3) vision for monitoring, (4) vision for focused research and (5) visions for phased implementation.

The identity and summary visions for each ecosystem element follow in Table 1.

TABLE 1. SUMMARY OF VISIONS FOR ADAPTIVE MANAGEMENT

Adaptive Management Element	Vision Summary
ADAPTIVE MANAGEMENT	The vision for adaptive management is to fully integrate indicators of ecological health, monitoring of indicators, focused research, and phased implementation in a manner to optimize the restoration of ecological health while anticipating and responding to changes resulting from increased knowledge of the system, how it works, and what its problems encompass.
INDICATORS	The vision for indicators of ecological health is to identify a suite of physical and biological measurements that, if monitored through time, will provide a strong indication of the ecological health of the Bay-Delta system and the status of important ecological processes, habitats, fish, wildlife and plant species, and extent of adverse influence of stressors in order to judge progress toward the recovery of depleted species and the overall health of the Bay-Delta.
MONITORING	The vision for monitoring the indicators of ecological health is to fully coordinate the existing diverse physical environmental and biological monitoring programs, to develop additional programs to fill any gaps, and to seek adequate levels of funding to conduct the monitoring during a 25-year span.
FOCUSED RESEARCH	The vision for focused research is to develop discrete study programs to collect infomation regarding important physical and biological resources and processes in the Bay-Delta system in order to increase our understanding of how the system works and to identify new or modified approaches to restoring depleted species and ecological health.

Adaptive Management Element	Vision Summary
PHASED IMPLEMENTATION	The vision for phased implementation is to develop an intelligent framework by which to logically select programs and projects for funding and implementation in order to optimize benefits from actions designed to restore ecological health and reduce conflicts between competing resources.



INTRODUCTION

Ecosystem management is the process of taking actions to preserve, sustain, enhance, and restore ecological resources and provide for human needs in an ecosystem such as the Bay-Delta. Adaptive ecosystem management is adjusting these management actions as the process unfolds and results are obtained (Holling 1978; Walters 1986; Lee 1993). It is an interactive approach to decision making that incorporates feed-back loops to evaluate actions and inject new information as it becomes available. Adaptive management involves implementing the actions most likely to achieve ecosystem management goals, given today's knowledge. Experimental management (focused research) is included where improved knowledge is essential. Results are monitored and actions modified as necessary to achieve management goals. In the ecosystem health vernacular, ecosystem managers diagnose, treat, monitor response to treatment, and then adjust the treatment as needed to attain the desired result.

The most important step in the CALFED Ecosystem Restoration Program Plan (ERPP) is to construct a comprehensive framework that includes policy and management decision-making based on existing or newly developed scientific and technical information. This framework to make decisions and implement the ERPP is called adaptive management.

Adaptive management for the ERPP and other CALFED common programs has a dual nature. First, adaptive management is a philosophical approach towards restoration that acknowledges we need to better understand the Bay-Delta watershed to succeed in restoring ecosystem health, but that we will proceed with restoration program using existing information and while gathering the knowledge that we lack. Although we know much about the watershed (its ecological processes, habitats, and species), we do not know everything we need to successfully restore ecosystem health. The adaptive management philosophy accommodates the status of knowledge and provides an avenue to obtain the necessary knowledge (and experience) through the duration of the implementation period.

Secondly, adaptive management is a tightly structured decision-making process that includes important components to identify indicators of ecosystem health (indicators), a program for monitoring indicators of ecosystem health (monitoring), a program for implementing research to gather new or additional information (focused research), and a process to optimize the implementation projects through time (phased implementation). In its practical application, adaptive management must be strongly based on the scientific method (see inset on next page).

VISION

The vision for adaptive management is to fully integrate indicators of ecological health, monitoring of indicators, focused research, and phased implementation in a manner to optimize the progress toward meeting ERPP implementation objectives (Table 1) and restoration of ecological health while anticipating and responding to changes resulting from increased knowledge of the system, how it works, and what its problems encompass.

> *SCIENTIFIC METHOD (noun)*
>
> The principles and empirical processes of discovery and demonstration considered characteristic of or necessary for scientific investigation, generally involving the observation of phenomena, the formulation of a hypothesis concerning the phenomena, experimentation to demonstrate the truth or falseness of the hypothesis, and a conclusion that validates or modifies the hypothesis.
>
>

Adaptive management will involve stakeholders and resource managers working together in redirecting program actions in response to increasing ecological information (Holling 1978; Walters 1986; Walters and Holling 1990).

Because of the difficulties and uncertainties involved in ecosystem management, adaptive management has been suggested and widely adopted as the standard approach to ecosystem management (Everett et al. 1994). Adaptive management is a key component of ecosystem management as it provides a decision support system for stakeholders and resource managers (Wondolleck 1988). Adaptive management addresses risks and uncertainties by increasing opportunities to redirect management with new information (Everett et al. 1994).

To succeed an adaptive management program should include objectives for key resources, indicators, and actions with target implementation levels. Program objectives (implementation objectives) should be well defined, and should not be adjusted in the event success is not achieved; only targets, specific actions, and the implementation approach should be changed. The state of health the program hopes to achieve should not change, only the treatment program need be changed to ensure health goals are achieved. Targets may change as research and monitoring provide more indication as to the inherent relationships between indicators and key resources. Monitoring data are examined and reexamined with these objectives and targets in mind.

TABLE 1. ECOSYSTEM RESTORATION PROGRAM PLAN IMPLEMENTATION OBJECTIVES FOR ECOSYSTEM ELEMENTS.

This table displays the implementation objectives that are presented in the Ecosystem Restoration Program Plan, *Volume I: Visions for Ecosystem Elements.*

ECOLOGICAL PROCESS	IMPLEMENTATION OBJECTIVE
Central Valley Streamflows	restore basic hydraulic conditions to reactivate and maintain ecological processes that create and sustain habitat required for healthy fish, wildlife, and plant populations.

Natural Sediment Supply	provide sufficient quantities to riverine and estuarine systems to restore or reactivate stream channel meander and point bar formation, provide sediments to rebuild wetlands and shallow-water habitats, and provide for nutrient transport.
Stream Meander Corridors	maintain, improve, or restore natural stream meander processes to allow the natural recruitment of sediments, create habitats, and promote riparian succession.
Natural Floodplains and Flood Processes	modify channel and basin configurations to improve floodplain function along rivers and streams in the Sacramento-San Joaquin basin.
Central Valley Stream Temperatures	maintain, improve, and restore water temperature regimes to meet the life-history needs of aquatic organisms.
Bay-Delta Hydraulics	establish and maintain a hydraulic regime in the Bay-Delta to provide migratory cues, create and maintain habitat, and facilitate species distribution and transport.
Bay-Delta Aquatic Foodweb	maintain, improve, or restore the amount of basic nutrients available to estuarine and riverine systems to provide a sustainable level of foodweb productivity.
Upper Watershed Processes - Fire and Erosion	restore ecological processes in the upper watersheds to maintain and improve the quality and quantity of water flowing into the tributaries and rivers of the Sacramento-San Joaquin Delta and San Francisco Bay.

HABITAT ELEMENT	IMPLEMENTATION OBJECTIVE
Tidal Perennial Aquatic Habitat	increase the area of shallow-water and intertidal mudflat habitat to improve conditions that support increased primary and secondary productivity; provide rearing and foraging habitat, and escape cover for fish; and provide foraging and resting habitat, and escape cover for water birds.
Nontidal Perennial Aquatic Habitat	increase its amount in the Delta to provide improved foraging and resting habitat for water birds, particularly diving ducks, and help to restore and maintain the ecological health of the terrestrial and aquatic resources in and dependent on the Delta.
Delta Sloughs	protect and improve existing tidal slough habitat and restore a portion of the historical Delta slough distribution. Sloughs will be restored within tidally influenced freshwater emergent wetlands, mudflats, and seasonal floodplains.
Midchannel Islands and Shoals	protect and enhance existing remnant channel islands in the Delta. Prioritize island restoration starting with those that have greatest chance to be maintained by restored streamflow patterns, hydraulic conditions, sediment transport, and other restored ecosystem processes.
Saline Emergent Wetland	increase the area of saline emergent wetlands. The increased wetlands area would provide high-quality habitat for waterfowl, shorebirds, and other associated wildlife; provide rearing habitat, foraging habitat, and escape cover for fish; and expand the populations and range of associated special-status and State- and federally listed plant and animal species.

Fresh Emergent Wetland	protect and enhance existing wetlands by restoring tidally influenced freshwater emergent wetland in the Delta. This protected wetland would provide high-quality habitat for waterfowl, shorebirds, and other associated wildlife and rearing, foraging, and escape cover for fish. Populations and ranges of special-status and State- and federally listed plant and animal species would be increased.
Seasonal Wetlands	restore and manage this habitat type in the Delta to help restore and maintain the ecological health of the aquatic resources in and dependent on the Delta: restore foodweb and floodplain processes; reduce the effects of contaminants and water management on the Delta's aquatic resources; and provide high-quality foraging and resting habitat for wintering waterfowl, greater sandhill cranes, and migratory and wintering shorebirds.
Riparian and Riverine Aquatic Habitats	restore riparian scrub, woodland, and forest habitat along largely nonvegetated, riprapped banks of Delta island levees, the Sacramento and San Joaquin Rivers, and their major tributaries. Restored riparian habitat would provide shaded riverine aquatic cover for fish species, associated special-status plant and animal species, and other wildlife.
Inland Dune Scrub Habitat	improve low- to moderate-quality Delta inland dune habitat to support special-status plant and animal species and other associated wildlife populations.
Perennial Grassland	preserve and restore perennial grassland habitat in conjunction with restoration of wetland and riparian habitats in order to provide high-quality habitat conditions for associated special-status plant and wildlife populations.
Agricultural Lands	co-manage agricultural upland and wetland habitat to provide wildlife forage and resting area habitat for wintering and migrating waterfowl, shorebirds, and other associated wildlife in the Delta.

SPECIES TYPE	IMPLEMENTATION OBJECTIVES
Delta Smelt	ensure the recovery of this species, which is State- and federally listed as threatened in order to contribute to overall species diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.
Longfin Smelt	ensure the recovery of this species of special concern in order to contribute to overall species diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.
Splittail	assist in the recovery of this species, which is proposed for listing under the federal Endangered Species Act (ESA) in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

White and Green Sturgeon	restore the distribution and abundance of the white sturgeon to historical levels to support a sport fishery, and assist in the recovery of the green sturgeon, a California Department of Fish and Game species of special concern in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.
Chinook Salmon	contribute to the recovery of the Sacramento winter-run chinook salmon, a species listed as endangered under the federal and California Endangered Species Acts (ESAs) in order to ensure overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta. The objective is also to contribute to the restoration of Sacramento fall-run, spring-run, late-fall-run, and San Joaquin fall-run chinook salmon to support sport and viable commercial fisheries.
Steelhead Trout	achieve naturally spawning populations of sufficient size to support inland recreational fishing and fully use existing and restored habitat areas in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.
Striped Bass	restore its population levels to those of the 1960s to contribute to a recreational fishery in the Bay-Delta in order to reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.
American Shad	to maintain naturally spawning populations that support sport fisheries similar to fisheries that existed in the 1960s and 1970s in order to contribute to the recreational use of the Bay-Delta
Resident Fish Species	maintain and restore the distribution and abundance of resident native fish species, such as Sacramento blackfish, hardhead, tule perch, and Sacramento perch, and non-native species, such as white catfish, largemouth bass, and threadfin shad, in order to support a sport fishery and healthy forage populations.
Marine/Estuarine Fishes and Large Invertebrates	maintain, improve, and restore populations of these species to levels that existed in the early 1980s in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.
Bay-Delta Aquatic Foodweb Organisms	restore the estuary's once-productive food base of aquatic algae, organic matter, microbes, and zooplankton
Western Spadefoot and California Tiger Salamander	assist in the recovery of both species of special concern in the Bay-Delta in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.
California Red-Legged Frog	assist in the recovery of this federally listed threatened species in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Giant Garter Snake and Western Pond Turtle	assist in their recovery in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.
Swainson's Hawk	assist in the recovery of this State-listed threatened species in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
Clapper Rail	assist in the recovery of this State- and federally listed endangered species in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
California Black Rail	assist in the recovery of this State- listed threatened species in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
Greater Sandhill Crane	assist in the recovery of this State-listed threatened species in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
Western Yellow-Billed Cuckoo	assist in the recovery of this State-listed endangered species in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
Bank Swallow	assist in the recovery of this State-listed threatened species in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
Suisun Song Sparrow	assist in the recovery of this State- and federally listed endangered species in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
Salt Marsh Harvest Mouse	assist in the recovery of this State- and federally listed endangered species in order to contribute to overall species diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
Riparian Brush Rabbit	assist in the recovery of this State-listed endangered species in the Bay-Delta in order to contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.
Shorebird and Wading Bird Guild	maintain healthy populations in order contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.
Waterfowl	maintain healthy populations at levels that can support both consumptive and nonconsumptive uses, and contribute to the overall health and beneficial uses of the Bay-Delta

Upland Game	maintain healthy populations at levels that can support both consumptive and nonconsumptive uses
Neotropical Migratory Bird Guild	maintain healthy populations in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.
Lange's Metalmark, Delta Green Ground Beetle, and Valley Elderberry Longhorn Beetle	assist in maintaining populations of the Lange's metalmark, a federally listed endangered species, by increasing its abundance, and assist in the recovery of the delta green ground beetle and Valley elderberry longhorn beetle, both federally listed endangered species, by increasing their populations and abundance in order to contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land water in the Bay-Delta.

STRESSOR TYPE	IMPLEMENTATION OBJECTIVE
Water Diversions	reduce entrainment of juvenile fish into water diversions in order to increase survival and population abundance to levels that contribute to the overall health of the Delta and reduce conflicts for other beneficial uses of land and water.
Dams, Reservoirs, Weirs, and Other Human-Made Structures	increase the connection of upstream spawning and rearing habitat with the mainstem rivers in the Sacramento-San Joaquin basin in order to increase success of adult spawners and survival of juvenile downstream migrants.
Levees, Bridges, and Bank Protection	reestablish or reactivate geomorphological processes in artificially confined channel reaches to maintain hydrologic connectivity with the natural floodplain.
Dredging and Sediment Disposal	reduce loss and degradation of aquatic habitat and vegetated berm islands caused by dredging activities and reduce impacts of dredging activities on aquatic resources during critical spawning and rearing periods and in sensitive areas.
Gravel Mining	reduce the adverse effects of instream gravel mining to improve gravel recruitment, cleansing, and transport processes, contribute to natural stream sediment supply, and improve other stream channel processes.
Invasive Aquatic Plants	reduce the adverse effects of these species on native plants to increase and maintain the productivity of the aquatic foodweb, preserve suitable fish habitat structure, and provide quality habitat conditions for native submergent and emergent plants.
Invasive Aquatic Organisms	reduce introductions of non-native species in order to protect and provide sustainable populations of native species.
Invasive Riparian and Salt Marsh Plants	reduce populations of invasive non-native tree and shrub species that compete with native riparian vegetation.
Non-Native Wildlife	reduce the abundance of non-native wildlife species to maintain and expand the diversity or abundance of native species or the ecological stability of native habitats.

Predation and Competition	reduce the loss of juvenile anadromous and resident fish and other aquatic organisms from unnatural levels of predation in order to increase survival and contribute to the restoration of important species.
Contaminants	reduce concentrations and loading of contaminants in the aquatic environment and the subsequent bioaccumulation by aquatic species, increase survival of aquatic species, and eliminate public health concerns resulting from accumulation of toxins in tissues.
Fire	reduce the acreage and frequency of catastrophic wildfires to reduce their adverse effects on fish and wildlife and their habitats.
Fish and Wildlife Harvest	regulate harvest of fish and wildlife to the extent necessary to avoid impairing the reproductive capacity of the population in relation to available habitat.
Artificial Fish Propagation	reduce the potentially adverse effects of stocking artificially produced fish throughout Central Valley rivers and streams in order to increase the survival of naturally produced fish, contribute to long-term restoration goals, and maintain the genetic diversity of naturally producing populations of chinook salmon and steelhead populations.
Disturbance	reduce human activities that adversely affect wildlife behavior or cause habitat destruction, increase reproductive success, and contribute to restoration of important species.

Effective adaptive management requires well-defined success criteria, long-term comprehensive monitoring plans, comprehensive research plans, and a coordinating management team.

NEED FOR ADAPTIVE MANAGEMENT

The primary need for adaptive management is to provide a robust process to maximize potential successes of the ERPP. Adaptive management provides a process for action implementation, monitoring, evaluation, and program evaluation and readjustment that helps to insure program goals and objectives will be met. It provides for rapid feedback of information and adjustments in program actions and implementation levels to keep the program on track. Adaptive management helps in dealing with the inherent uncertainties of complex ecosystems. When causes of specific ailments are unknown and difficult to diagnose, then the solution may become evident from the response to treatments. Adaptive management provides needed feedback on the treatment regime and the amount of treatment required for restoration. In ecosystem restoration programs there are often questions of how much habitat is needed and to what extent it should be restored. Adaptive management provides for experiments and monitoring to address these questions. There may also be questions on techniques and engineering feasibility. Pilot studies and experiments can provide an arena in which to work out the technology bugs and refine the methods.

Adaptive management provides for flexibility in the restoration program. It allows a step by step approach where solutions can be implemented in phases for cost or technical reasons. Flexibility comes from ability to adjust the program as needed.

UNCERTAINTY

Uncertainty about the future can be addressed with adaptive management. Weather and rainfall are uncertain. Even such things as global warming with its accompanying sea rise are changes to be considered. Further invasion of exotic species are likely. Since we cannot be sure how such change will occur, we must anticipate adapting to the changes as they occur. Whether the future is chaotic or potentially predictable, adaptive management provides a solution.

Lack of sufficient knowledge about complex ecosystems such as the Bay-Delta brings uncertainty to a restoration program that can be alleviated through adaptive management. Specific hypothesis can be tested in experimental actions to further understanding of the underlying cause-and-effect mechanisms that control the target ecosystem. There may be many hypotheses to test before the program can proceed toward success. Probing into uncertainty with experiments should provide needed information. For the least understood problems, several treatments may be proposed, and responses monitored through key vital signs or indicators. More serious problems may require more aggressive or even experimental treatments.

There is also uncertainty relative to the potential benefit, costs and indirect effects of specific actions. Actions may fail to achieve objectives and there will be a need to shift direction to meet objectives. Technical feasibility may be in question for specific actions. Or we may not know how to implement an action. The potential effectiveness of specific actions may also be in question. Actions may also appear to be ineffective at a test scale, but be effective on a broader scale of implementation. A phased or experimental approach would allow some action to be directed toward problems before there is complete agreement on the overall solution. Diverse opinions may call for multiple approaches toward solving specific problems. An adaptive approach can also help to overcome uncertainties related to state. federal, and local restrictions and regulatory requirements by implementing programs incrementally.

The potential for risk or failure increases with uncertainty. Adaptive management is an effective tool to minimize risks in an ecosystem restoration program. Risks such as indirect effects of actions can be identified from test programs. For example, increasing flows in one season usually means decreasing flows in another. Testing programs can identify risks with minimal impacts. Irreversible negative impacts are minimized under an adaptive management approach. We should be particularly aware of actions that preclude future options. With stakes high and funding limited, adaptive management provides a cautious and potentially reversible approach. Management must balance uncertainty and risks of failure with risks of no action.

Testing and monitoring under adaptive management verify that implementation objectives and targets are being met and reveal indicators and targets remain appropriate representatives of the key resources and their goals.

Adaptive management provides opportunities to fund the program in stages. Commitments are often easier to obtain after each stage is proven successful and optimism builds for the next. Opportunities for cooperative funding or combining programs also come up that may improve the overall funding and potential success of the program. Unprofitable expenditures are limited. Costly long-term commitments that provide little or no benefit are avoided.

Adaptive management allows for periodic adjustments to ensure equitable use of resources. Staging of program implementation provides opportunities to monitor equity and make corrections.

POTENTIAL DRAWBACKS OF ADAPTIVE MANAGEMENT

There are several potential drawbacks of adaptive management.

- Small test efforts may not provide sufficient testing of the diversity of important ecosystem functions in a complex ecosystem such as the Bay-Delta.
- A phased approach may delay implementation and could allow declines in the health of important ecosystem components.

- Benefits of some aspects of the program may be a long time in coming or may not even be detectable, which may lead to dropping valuable program elements.

- Information and analytical needs of adaptive management are extensive, requiring large amounts of monitoring and research.

- Funding for an uncertain future and for the necessary monitoring and research may be difficult to obtain.

- Obtaining consensus and management direction and support on future modifications of actions may be difficult.

ADAPTIVE MANAGEMENT IN THE ECOSYSTEM RESTORATION PROGRAM PLAN

The ERPP approaches restoration of the Bay-Delta from an ecosystem perspective, because of the system's large size and complexity. The traditional piece-meal approach of addressing multiple local area restorations will not work in a large, complex, and integrated ecosystem such as the Bay-Delta and its upstream watersheds. This has been obvious to those involved with the Bay-Delta problems over the past several decades, and adaptive management has been a common practice at least at the individual project level. Previous efforts at adaptive management, such as the State Water Resources Control Board standards process, usually had too narrow a focus to provide an ecosystem level of restoration. The ERPP offers an opportunity to extend this approach to restoration of the ecosystem at the basin-wide level with a much broader focus.

The goal of the program is to prevent further deterioration of the Bay-Delta ecosystem and to restore as much of the ecosystem health as possible. Knowledge and funding are needed to accomplish this goal. However, since knowledge and funding are limited resources, adaptive management will maximize the efficiency and cost effectiveness of the effort.

Adaptive management is a necessity of the ERPP, because of uncertainty about the causes of the ills of the Bay-Delta ecosystem and the inability to predict responses to proposed remedies and actions. A substantial number of the ERPP proposed actions will necessarily be implemented as "experiments" because of highly uncertain outcome and benefit. Actions are designed to meet specific objectives, but responses may be uncertain. For example, identified declines in many fish populations have been related to a combination of diverse factors with the cause-and-effect mechanisms and roles of each factor being relatively unknown. Fish declines coincide with changes is flow and habitat conditions, but the specific role of each is unknown. Experiments will be needed to direct the program toward actions that provide the most improvement in fish populations.

Because of the difficulties in answering these questions, the program will proceed on available information and theories. Adaptive management will test these theories through controlled experiments and pilot studies, rather than the wholesale implementation of actions.

With limited resources (e.g. dollars, land, water, time) a careful approach is necessary for success. Priorities and degree of experimentation in the program will depend on the extent to which each resource is limited. With many possible directions toward restoration, those routes with the most promise and equity must be found. The challenge will be to find an effective solution that is equitable, balanced, and least costly. Coming up with such a solution will require knowledge of factors and interactions that presently does not exist.

Adaptive management can help increase our knowledge and overcome uncertainty as the results of early actions are monitored. However, adaptive management is not a prescription to conduct a series of very modest restoration projects and monitor results until all uncertainty is dispelled. A system as large, complex, and troubled as the Bay-

Delta demands that we pursue large-scale implementation of actions most likely to achieve ecosystem management objectives. A less ambitious approach would not yield observable results and would result in an unacceptably long recovery period for the ecosystem.

Not all actions will be experiments. Some early steps will be to implement proven solutions to serious problems that have already been identified. Actions such as the screening of unscreened diversions may require some degree of experimentation to work out details of cost, engineering feasibility, and ecological considerations, but necessary actions are relatively clear.

Adaptive management will allow more focus on ecosystem functions: those factors that are necessary to maintain habitat and biological processes of important fish and wildlife populations. This is essential for successful ecosystem restoration.

Adaptive management will also provide more focus on geographic differences and watershed units. The experimental approach focuses on specific watersheds (ecological units) or watershed units (ecological zones). Focusing intensively on a watershed provides a comprehensive view of the status and behavior of program actions without the need to extend efforts to the entire system. Upon testing, the program can be expanded within a watershed and to other watersheds, recognizing the inherent differences among the watersheds.

In the overall restoration program, adaptive management should be implemented on a project-by-project basis, as each project may have its own specific needs for monitoring and research, as well as risk and uncertainty with regard to technical feasibility and cost.

An adaptive management approach will mean the program will proceed on a broad front with many pilot and experimental projects at the watershed level that test the effectiveness and technical feasibility of actions. As the program matures, larger scale projects will be pursued as information is gained from early pilot studies and experiments. This approach will not preclude early implementation of large scale projects that address identified needs and have a sound technical basis. There is considerable information available to implement an adaptive approach immediately for some program elements. Review and analysis of such information may preclude the need for some "experiments."

To be successful, adaptive management in the ERPP will need institutional structures to carry out the program, get funding, and make future decisions and adjustments. The CALFED program will develop the supporting institutions from existing agencies and stakeholder groups. If these existing structures are insufficient, new institutions may need to be created.

REQUIREMENTS OF THE ADAPTIVE ECOSYSTEM MANAGEMENT PROGRAM

IMPLEMENTATION OBJECTIVES, TARGETS, AND PROGRAMMATIC ACTIONS

A vision for the future, expressed as ERPP implementation objectives, is needed to guide the adaptive management program. Targets designed to meet the implementation objectives are the basis for experiments to test mechanisms for achieving the implementation objectives. Implementation objectives are fixed through time and will not change. Targets, however, have been designed to accommodate new information and successes in reaching the implementation objectives. Targets can change through time and can be reached in a variety of ways. Programmatic actions are very flexible and require prefeasibility studies and option analyses to identify site-specific actions for implementation.

HYPOTHESES

Where uncertainty prevails and first steps toward objectives require pilot studies and experiments, scientific and testable hypotheses should be developed.

PRIORITIES

Priorities will be based on critical needs of important ecosystem elements. Where research is needed before actions can be taken to preserve important resources, this research will be given high priority.

MONITORING

Monitoring linked to hypotheses testing and validation and focused research is an essential part of adaptive management. It provides information on the relative success toward reaching objectives and provides key information on the process (e.g., costs, risks, schedule).

RESEARCH

Like monitoring, focused research is an important element of adaptive management. Research may be needed to develop effective monitoring techniques, establish causes, or test techniques that may have uncertain outcomes.

MODELS

Because of the lack of available information and understanding of complex ecosystems, ecological modeling tools can be valuable in an adaptive ecosystem management program. Models are used to predict system responses through manipulation of controlling or limiting factors based on available information or theory. Models can help guide the program toward areas of uncertainty and document what is learned. Uncertainties can be built into a model and then tested through direct manipulation of the ecosystem. Models also need verification through experiments. Models also test the accuracy of information being used in the program. Models can also simulate various possible outcomes to provide a measure of confidence.

Everett et al (1994) suggests using simple risk analysis models to assist decision makers in determining the relative success of experiments in meeting goals and objectives. As with any model, assumptions and conclusions should be verified to ensure it is a valuable and accurate tool.

SCALES OF ADAPTIVE MANAGEMENT

Adaptive management, as implemented through the ERPP, will occur at a variety of scales:

- landscape level,
- ecological zone level,
- ecological unit level, and
- ecosystem element level.

At the landscape level adaptive management must broadly integrate actions, monitoring results, focused research, and phased implementation throughout the ERPP study area.

At the ecological zone level, adaptive management must be able to synthesize information from a smaller subset of the ERPP study area. Each ecological zone may contain from two to eight ecological units and information gained in one unit must be evaluated for its application to other units in the zone.

At the ecological unit level, adaptive management principles must be able to provide guidance and evaluations based on the specific actions within the unit and the broader perspective found at the ecological zone and ERPP study area levels.

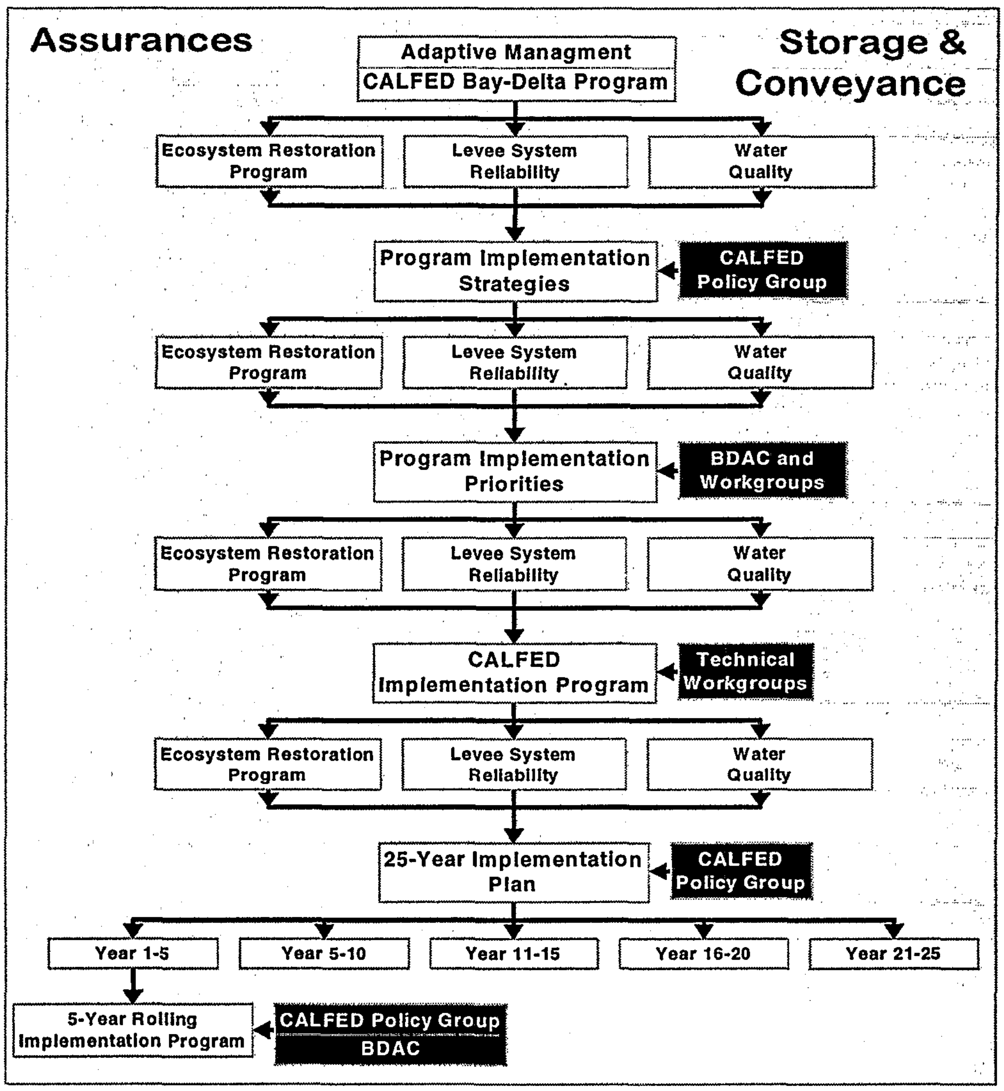
At the ecosystem element level, adaptive management must be able to evaluate and provide guidance for actions directed at specific ecosystem processes, habitats, and species in the units, zones, and ERPP study area.

One of the most difficult tasks in the application of adaptive management is the integration of knowledge over a wide range of ecological scales. At the highest ecological scale, adaptive management can provide a broad view that may lack fine focus or miss details that have great importance at the unit or ecosystem element level. At the lowest level, adaptive management can provide a very fine resolution that does not incorporate knowledge from elsewhere in the ERPP study area.

APPLICATION OF THE ADAPTIVE MANAGEMENT PROCESS TO THE ERPP

Adaptive management is the most important tool to be used during implementation of the ERPP. In adjusting the process of adaptive management to

Adaptive Management Process Schematic for CALFED Bay-Delta Program



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the CALFED ERPP, consideration must be given to the role and influence of two other important CALFED components: assurances and the preferred alternative for storage and conveyance.

ASSURANCES

The CALFED adaptive management process will be directed and constrained by the slate of assurances which is being developed.

Add to this later>

PREFERRED ALTERNATIVE FOR STORAGE AND CONVEYANCE

The CALFED adaptive management process will be shaped by the selection of the preferred alternative for storage and conveyance. Storage components can result in restructuring the phased implementation program upstream of the Delta or in the Delta. South of Delta storage may not influence restoration program implementation in the Delta.

PROPOSED CALFED ADAPTIVE MANAGEMENT PROCESS FRAMEWORK

The Ecosystem Restoration Program adaptive management process is a subset of the overall CALFED adaptive management process. The major components of the process include adaptive management arms for the ERPP, levee system reliability, and water quality. Each of these arms will be shaped by the assurance package developed for the long-term implementation program and by the selection of the preferred alternative for storage and conveyance.

At the programmatic level, the CALFED adaptive management process incorporate policy and decision making, technical recommendations and decisions, and review by a scientific advisory panel. The structure of the proposed CALFED adaptive management process is presented in the following figure.

At the highest level, the CALFED adaptive management process is an integration of the three major common programs: ecosystem restoration, levee system reliability, and water quality.

STRATEGIES

For each component within the adaptive management process, CALFED (and the participating agencies and stakeholders) need to develop implementation strategies. These strategies provide the pathway to successful implementation. For some elements, implementation programs exist, while for others, no implementation programs have been developed yet. The basic CALFED strategy for each component will likely be to build on existing programs, bring these programs up to a level to meet CALFED objectives, and to augment program staffing levels and fund availability for implementing projects. Likewise, in areas where no implementation program has been developed, the CALFED strategy may be to encourage the most responsible agency to establish an implementation program and to provide funding for projects.

Within the Ecosystem Restoration Program, implementation strategies need to be developed for the following types of large scale programs (list not complete):

- upper watersheds
- natural sediment supplies,
- riparian and riverine aquatic habitat restoration,
- floodplains and flood processes (including set back levees),
- water acquisition,
- stream meander corridors,
- land acquisition,
- conversion of acquired land to various types of habitat,
- cooperative management of agricultural lands,
- gravel mining,
- invasive aquatic species,
- invasive aquatic plants,

- invasive riparian and saltmarsh plants,
- unscreened diversions,
- dams, reservoirs, weirs, and other human-made structures (fish passage), and
- harvest.

The other common programs also have a strong link to ecosystem restoration. For example, many elements of the ERPP recommendations for contaminants will be addressed by the water quality common program, and recommendations for levee setbacks and acquisition of land in the Delta for conversion to habitat will be closely linked to the levee system reliability common program.

In developing the implementation options for each common program, CALFED will develop specific implementation strategies for major subcomponents. For example, CALFED will develop a strategy for addressing the ecological problems caused by unscreened diversions. In developing this strategy, CALFED will assess the legal basis and authorities of existing unscreened diversion programs, review their funding and staffing levels, assess their successes, and judge their anticipated ability to contribute to CALFED objectives. As a result CALFED could recommend either developing a new screening program to meet CALFED objectives or assist and augment existing programs

The California Department of Fish and Game has statutory responsibility under provisions of the Fish and Game Code to require diverters or to assist diverters in installing screens on diversions. The DFG program has staff and expertise in abating unscreened diversion. DFG has also develop a plan and priority scheme to address unscreened diversions.

The U.S. Fish and Wildlife Service is required under Section 3406(b)(13) of the Central Valley Project Improvement Act (CVPIA) to assist the State of California in implementing the State's unscreened diversion program. The CVPIA is limited to screening for anadromous fish.

In developing the strategy for unscreened diversions, CALFED will assess existing program and administrative structure to determine if the unscreened diversion programs can reasonably meet CALFED ecosystem restoration objectives. The final assessment could recommend a variety of approaches that range from significant changes in the existing structure of the unscreened diversion programs to CALFED only augmenting existing program staffing level and annual fund availability for installing screens.

SETTING IMPLEMENTATION PRIORITIES

After implementation strategies are set and agreed to by the participating agencies and stakeholders, restoration priorities can be established. Again, review of existing programs is needed to determine existing priorities, identify any legally mandated priorities, and to augment the existing priorities to incorporate CALFED program needs. Many areas proposed by CALFED are new or different enough to require the creation of new priority setting schemes.

The first pass at setting priorities needs to be programmatic in nature and consider the 25-year implementation phase of the program. Stressors that are known sources of mortality to fish, wildlife, and plant resources could have a high priority early in the program that lessen in future years as the problems are abates. Likewise, projects that will take a decade or more to implement, such as land acquisition and conversion to habitat, may benefit from having a high priority early in the program.

Regardless, the programmatic priority scheme needs to be multidimensional by considering the 25-year implementation period, projected availability of funding, needs of endangered species, assurances, and preferred alternative for storage and conveyance.

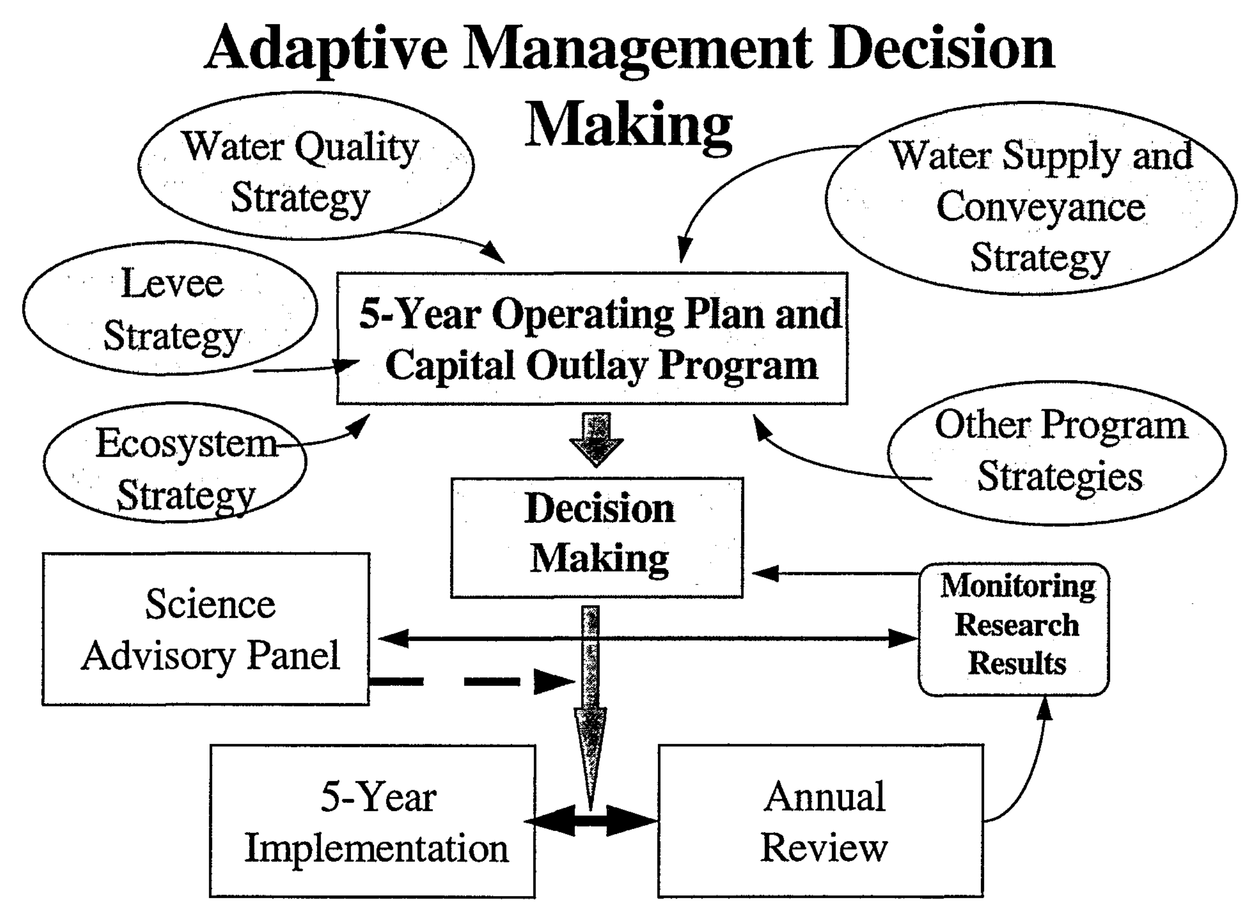
IMPLEMENTATION PROGRAM

Development of the 25-year implementation program needs to focus on structure and process.

Structure of the program may entail establishing an independent entity to oversee implementation of restoration actions in the Sacramento-San Joaquin Delta and its watershed.

25-YEAR IMPLEMENTATION PLAN

After the 25-year implementation structure and process are developed, a programmatic 25-year implementation plan can be developed. The final section in this volume discusses phased implementation and provides addition information relevant to developing this long-term program.



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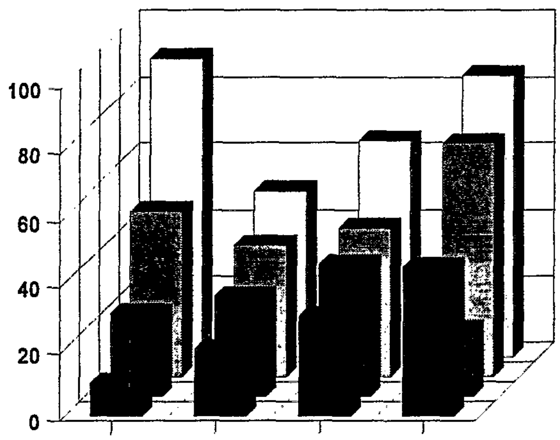
Ecosystem Health



INTRODUCTION

A comprehensive suite of indicators is essential to:

- explicitly translate broad goals into measurable performance parameters that encompass most or all of the significant characteristics of the ecological system;
- decrease the dependence of the definition of success of the program onto any single indicator;
- provide guiding information for long-term, adaptive management strategies.

Descriptions of indicators must include the appropriate metric (what will be measured) and state how the metric relates to desired products (how the measured variable reflects the desired ecological condition). Consideration of the appropriate metric can greatly help in identifying appropriate levels of restoration effort, especially if the metric directly relates a desired condition to a condition of the indicator.

An important secondary role of these metrics is to help develop 'indicators' that can be used to keep public and policy makers informed of the success of restoration actions. It is this sense of a broad surrogate for diverse ecosystem functions that is meant by the term 'indicator' in some other restoration efforts. In the ERPP, the word 'indicator' to mean direct measures of ecosystem performance for each parameter identified in the implementation objectives.

We have attempted to identify the types of performance metrics appropriate for each of the CALFED Implementation Objectives for ecosystem restoration and to identify the sorts of biological knowledge that could guide selection of suitable levels of each indicator. Many indicators will need to be specific to particular areas within the watershed while others reflect broader ecological units. Focused research will be needed to assess the meaning of some indicator responses and to guide future restoration actions. All indicators must be readily measured in the field and monitoring programs may need to be modified to encompass all indicators.

Earlier work on indicators appropriate for this system have identified broad ecological attributes of the ecosystem (Levy et al. 1996). This earlier work also stressed the need to assess ecological performance at several ecological scales (local habitat, zones, and landscapes). CALFED's implementation objectives are focused on finer levels of details and use 14 ecological zones (geographical areas) to group the objectives. CALFED objectives and indicators should be comprehensive and consistent with the earlier work. They must also be capable of reflecting performance of the system at different ecological scales. Table 1 describes the correspondence between the ecological attributes (Levy et al. 1996) and CALFED's restoration elements. Table 2 under Habitats was developed for use in identifying habitat indicators, and assesses which indicators apply to different scales of responses.

TABLE 1. COMPARISON OF CALFED ECOSYSTEM ELEMENTS WITH THE SUITE OF ECOLOGICAL ATTRIBUTES DEVELOPED BY THE BAY INSTITUTE AND ENVIRONMENTAL DEFENSE FUND.

Bullets (■) identify CALFED elements that relate to the corresponding ecological attribute, items without bullets identify equivalent elements and attributes, italics identify stressors relevant to the corresponding elements and attributes

Ecological Attributes (per Levy et al. 1996)	CALFED Ecosystem Elements
Natural Water flow regime	■ *Central Valley streamflows* ■ *Natural sediment supply* ■ *Floodplains and flood processes* ■ *Stream meander corridors* ■ *Stream temperatures* ■ *Dams, reservoirs, weirs, and other human-made structures* ■ *Water diversions*
Natural sedimentation regime	■ *Natural sediment supply* ■ Gravel recruitment ■ Gravel cleansing and transport ■ *Dams, reservoirs, weirs, and other human-made structures* ■ *Dredging and sediment disposal* ■ *Gravel mining*
Natural successional processes	■ *Stream migration corridor* ■ *Natural sediment supply* ■ *Levees, bridges and bank protection* ■ *Dams, reservoirs, weirs, and other human-made structures* ■ *Water diversions*
Nutrient budget and cycling	■ *Bay-Delta aquatic foodweb* ■ *Riparian and riverine aquatic habitat* ■ *Tidal perennial aquatic habitat* ■ *Saline emergent habitat* ■ *Seasonal wetlands* ■ *Floodplains and flood processes* ■ *Levees, bridges and bank protection*
Transport of organic materials and organisms	■ *Central Valley streamflows* ■ *Levees, bridges and bank protection* ■ *Land use* ■ *Gravel mining*
Food web support	■ *Bay-Delta aquatic foodweb* ■ *Riparian and riverine aquatic habitat* ■ *Tidal perennial aquatic habitat* ■ *Saline emergent habitat* ■ *Seasonal wetlands* ■ *Floodplains and flood processes*
Water quality	■ *Water temperature* ■ *Contaminants* ■ *Dams, reservoirs, and other man-made structures*

Ecological Attributes (per Levy et al. 1996)	CALFED Ecosystem Elements
Habitat quality	■ Tidal perennial aquatic habitat ■ Nontidal perennial aquatic habitat ■ Saline emergent wetlands ■ Fresh emergent wetlands ■ Delta Sloughs ■ Midchannel islands and shoals ■ Seasonal wetlands ■ Perennial grasslands ■ Riparian and riverine aquatic habitat ■ Agricultural lands ■ *Levees, bridges and bank protection* ■ *Dredging and sediment disposal* ■ *Land use* ■ *Gravel mining*
Habitat extent	■ *Tidal perennial aquatic habitat* ■ *Nontidal perennial aquatic habitat* ■ *Saline emergent wetlands* ■ *Fresh emergent wetlands* ■ *Delta Sloughs* ■ *Midchannel islands and shoals* ■ *Seasonal wetlands* ■ *Perennial grasslands* ■ *Riparian and riverine aquatic habitat* ■ *Agricultural lands* ■ *Dams, reservoirs, weirs, and other human-made structures*
Habitat diversity	■ *Levees, bridges and bank protection*
Habitat connectivity	■ Vegetation succession, overbank flooding, and floodplain inundation ■ *Levees, bridges and bank protection* ■ *Land use* ■ *Dams, reservoirs and other man-made structures* ■ *water management and diversions*
Integrity of native biotic community	■ *Chinook salmon* ■ *Steelhead trout* ■ *Native non-game fish* ■ *Native game fish* ■ *Green sturgeon* ■ *Sacramento splittail* ■ *Marine fish/large invertebrates* ■ *White sturgeon* ■ *Other representative species* ■ *Invasive aquatic plants* ■ *Invasive aquatic organisms* ■ *Invasive riparian and salt marsh plants* ■ *Non-native wildlife* ■ *Predation and competition* ■ *Artificial fish production*

Ecological Attributes (per Levy et al. 1996)	CALFED Ecosystem Elements
Support of sustainable harvest	■ *Chinook salmon* ■ *Steelhead trout* ■ *Green and white sturgeon* ■ *Striped bass* ■ *American shad* ■ *Other resident species* ■ *Harvest of fish and wildlife* ■ *Artificial fish production*

TYPES OF ECOSYSTEM ELEMENTS

ECOSYSTEM PROCESSES

Many ecosystem processes are substantially reduced from levels that would allow the Bay-Delta watershed and estuary to perform its desirable historical functions. These ecosystem processes generally lead to easily measured ecosystem products that are suitable indicators. In many cases, the level of performance necessary to achieve desirable conditions are of a stepwise nature or with a range within which benefits accrue rapidly in response to restoration efforts.

CENTRAL VALLEY STREAMFLOW

IMPLEMENTATION OBJECTIVE

The implementation objective for Central Valley streamflows is to restore basic hydraulic conditions to reactivate and maintain ecological processes that create and sustain habitat required for healthy fish, wildlife and plant populations.

INDICATORS

Indicators for Central Valley streamflows will include a comparison of actual streamflows to a preferred hydrograph that integrates the ecological functions supported by streamflow. The role of streamflow in maintaining aquatic and riparian habitats will be reflected in the interaction of streamflow with geometry to produce aquatic habitats. An additional function of streamflow is the oxygenation of redds, principally of concern in lower elevations. The habitat requirements of fish, wildlife, and plant populations within each ecological zone or unit will provide the necessary quantification.

- Upstream. The presence, distribution, and quality of riffle-pool-run sequences will be appropriate for upstream sites. These sequences can only exist where streamflows are high and variable enough to mobilize the bedload and support erosional and depositional processes. For particular species or communities, the Instream Flow Incremental Methodology (IFIM) might be used to quantitatively describe different velocity-based habitats.

- Lower elevation streams. Meander lengths and transects will reflect the role of streamflow alterations in lower reaches of streams and rivers. Maintenance of local meander processes will integrate both bathymetric and flow changes. For particular species or communities, the IFIM might be used to quantitatively describe different velocity-based habitats with particular river reaches.

- Oxygenation of redds is directly measurable in the field. This indicator would be well-measured also by the successful emergence of fry.

- Lower rivers and delta. Hectares of flooded vegetation, wetted perimeter, and bathymetric diversity would all reflect the interaction streamflow and physical changes in supporting habitats within the delta. Salinity regimes in the lower delta and upper bay (measured by X2 during the germination season) will be a necessary indicator of habitat suitability for particular habitats.

DATA REQUIREMENTS

Aerial photographs will be required in all zones, annually or biennially. Aerial photographs in lower elevations at 2- and 10-year floodflows. Oxygen levels in redds could be measured regularly at sites identified as problematic; fry emergence could be monitored through the operation of rotary screw traps. Which indicator is most appropriate at each site to reflect adequate oxygenation will vary from site to site. Salinity measurements in Suisun Bay from February through June in all years. River transects with velocity measurements at different flows may be required at sites where particular species are associated with particular velocity habitats.

NEXT STEPS

Collaborate with NMFS, USFWS, DFG and other knowledgeable parties to evaluate those sites where restoration efforts incorporating streamflow changes are needed. Identify sites where IFIM data will be needed. Identify or develop appropriate baseline aerial photographs. Identify salinity needs of indicator plants of estuarine habitats in order to evaluate salinity regimes needed in proposed restoration areas.

NATURAL SEDIMENT SUPPLY

IMPLEMENTATION OBJECTIVE

The implementation objective for natural sediment supply is to provide sufficient quantities to riverine and estuarine system to restore or reactivate stream channel meander and point bar formation, provide sediments to rebuild wetlands and shallow-water habitats and provide for nutrient transport.

INDICATORS

The sediment supply objective is addresses the restoration of stream channel meanders, formation of shallow habitats in depositional areas, and to provide for nutrient transport. Indicators therefore fall into three categories:

- Restoration of stream meanders in lower elevation streams. Sinuosity of stream channel measured by kilometers of river channel per standardized river kilometer will indicate success of restoration of meander processes. If erodible banks abut the stream channel, sediment supply is unlikely to limit meander processes.
- Formation of shallow areas. Accretion or erosion of particular sites would indicate whether the sediment budget was adequate to support restored habitats. Measures of sediment loads at each confluence would provide more information than needed for this indicator but would permit construction of a sediment budget that would be useful generally. Current velocities in the upstream reaches and wind-generated resuspension of sediments in San Francisco Bay are expected to supply adequate sediment loads to rebuild wetland habitats in either area. Sediment limitation is most likely to affect the success of wetland construction within the delta.
- Nutrient supply. Currently, evidence suggests that the ecosystem is seldom limited by sediment derived nutrient transport rates. However, a more productive ecosystem might become nutrient limited. Algal growth rates in bottles with and without augmented nutrient levels would permit monitoring of this potential problem.

This objective aims to ensure adequate abundance of good gravel conditions to support the spawning of anadromous fish. In addition, support of riparian succession and the maintenance of various instream habitats is also supported.

The principal intent of this objective will be reflected in the abundance of good spawning sites, measured through stream surveys of, perhaps, wintertime aerial photographs. This indicator is closely linked to the number of adults returning to spawn and their ability to use all spawning habitat. Redd superimposition and crowding at obstructions would be two supplementary indicators to assess whether gravel recruitment was providing the intended level of ecosystem support. As with nutrient supply, this parameter may become more important as ecosystem restoration leads to increased productivity.

The characteristics of suitable spawning gravels are supported by most of the significant processes associated with bedload movement in a river. Suitable sizes of gravel exposed at the surface, without armoring or excessive silt. These conditions can only persist the recruitment of gravel is adequate to balance loss, flows and sediment loads produce a washing away of fine sediments from the gravel and disturbance flows happen regularly enough to prevent armoring of the gravel.

DATA REQUIREMENTS

Aerial photographs would permit estimation of miles of stream channel and year to year changes in sinuosity. Such photographs would also be adequate to determine the lengths of river channel with erodible banks.

Aerial photographs would allow identification of the extent of shallow areas.

Measurements of algal growth rates in relation to augmented nutrient supplies have not been reported in this estuary for more than 10 years. Such studies would not need to be done often, but should be done as restoration efforts progress.

Much of the suitable gravels in mainstem rivers can be assessed from aerial photographs, paired with a lesser amount of ground-truthing of sedimentation and armoring conditions.

NEXT STEPS

Develop GIS system to estimate sinuosity and thalweg structure of present status of all major streams. Use GIS information to estimate maximum amount of restorable areas in each zone so that percentages of restoration can be easily reported from each new set of aerial photographs.

Assessment of current conditions of spawning gravels in the zones where spawning occurs and an assessment of the degree to which spawning gravels may limit the recovery of the population in each zone.

STREAM MEANDER CORRIDOR

IMPLEMENTATION OBJECTIVE

The implementation objective for stream meander corridorss is to maintain, improve, or restore stream meander processes to allow the natural recruitment of sediments, create habitats, and promote riparian succession.

INDICATORS

Dynamic sediment balances and the consequent creation and movement of habitat in river meanders would be monitored through aerial photographs and stream transects. The successful incorporation of successional stages would be determined through the characteristic percentages of each stage. Successful support of seral stages would be of particular interest at several scales of analysis.

DATA REQUIREMENTS

The measurements of stream meander success are discussed under natural sediment supply. The percentages of the various seral stages represented in a region can be evaluated from aerial photographs and will need to be calibrated to the number of years since the last floodflow adequate to produce the necessary disturbance pattern.

NEXT STEPS

As with floodplain inundation, this objective will require quantification of disturbance floodflow characteristics. On the ground sampling of actual plant community composition will probably need to occur on the same time scale as patterns of the disturbance floodflow events.

FLOODPLAINS AND FLOOD PROCESSES

IMPLEMENTATION OBJECTIVE

The implementation objective for floodplains and flood processes is to modify channel and basin configurations to improve floodplain function along rivers and streams in the Sacramento-San Joaquin basin.

This objective shares intent with several processes identified above. Unique to this is the prolongation of outflow regimes, the dissipation of flow velocity to reduce scour, and the occurrence of regular flows that disrupt armoring of bedload, and the creation of barren patches for the initiation of succession

INDICATORS

Seasonal inundation is currently a phenomenon associated with disaster conditions. Construction of seasonally floodable areas would integrate leveed areas with some broader streamside processes and provide the benefits of bypasses to areas subject to flooding. Indicators would include both reduced incidence of flooding protected areas at given levels of riverflow and number of days of inundation of specified areas at the 2 and 10 year flood flows.

Prolongation of flood flows would be reflected by period of inundation of floodplains, standardized to the 2- and 10-year flood flow events. Restoration of floodplain functions would be expected to lower the peak and extend the duration of outflow hydrographs. This indicator would be readily interpreted from river flow and delta outflow estimates.

Reductions in flow velocity would largely be a necessary correlate of extended flood flow duration, but measures of sediment transport and retention would be reflective of these actions. On a smaller scale, within stream channels, the reduction of scour due to high flow velocity would be well reflected in the below-water angle of channel sides. Reduction of this angle is a necessary pre-condition for the creation and stabilization of several habitats discussed in III. The angle representing stability will depend on site-specific characteristics, but in all cases this indicator should be scaled by its degree of conformance to a stable angle.

DATA REQUIREMENTS

Historical records would suggest the relationship between tributary outflow and the peak and duration of delta outflow.

NEXT STEPS

CENTRAL VALLEY STREAM TEMPERATURES

IMPLEMENTATION OBJECTIVE

The implementation objective for Central Valley stream temperatures is to maintain, improve, and restore water temperature regimes to meet the life history needs of aquatic organisms in Central Valley streams.

INDICATORS

Temperature needs of life history stages of various salmonids are well studied. The percentage of time and area within various watershed zones when temperatures (°C) are suitable for the anadromous fish in that zone is a straightforward measure of the success of this objective. As with sediment supply and streamflow, the indicators associated with this objective are probably among the best to monitor ecosystem restoration success over large geographic areas.

DATA REQUIREMENTS

Data appropriate for monitoring stream temperatures is already gathered by several agencies. These data should be coordinated with data on salmonid distribution.

NEXT STEPS

Temperature requirements of the various life history stages need to be compared with records of temperature from each spawning area to identify where temperature regimes need to be addressed as part of restoration.

BAY-DELTA HYDRAULICS

IMPLEMENTATION OBJECTIVE

The implementation objective for Bay-Delta hydraulics is to establish and maintain a hydraulic regime in the delta to provide migratory cues, create and maintain habitat, and facilitate species distribution and transport.

INDICATORS

Migratory cues for anadromous fish and transport of newly spawned eggs and larvae from spawning grounds to nursery areas are expected to improve by returning to a more natural hydrologic regime. Indicators therefore fall into two categories:

- Smolt success in reaching Chipps Island from each entry point into the delta, Additional information from radio-tagged wild fish would be extremely useful. Successful migration of adults would be another important indicator of successful restoration of migratory cues.
- Distribution of ichthyoplankton such that highest concentrations occur in suitable habitats.

DATA REQUIREMENTS

Catch rates of outmigrating salmon (both coded ware tagged and wild spawned) at Chipps Island and at each upstream entry point to the delta. For the Sacramento and San Joaquin this has historically been estimated by studies by FWS and others.

Egg and larval concentrations at key locations between the respective spawning and nursery sites of estuarine fish with a planktonic life stage. Delta smelt and striped bass are probably the two best species to use as surrogates for this process because of IEP experience in sampling for them.

NEXT STEPS

Review IEP data from historic years of good production of each species to determine catch rates and larval gradients consistent with successful recruitment.

BAY-DELTA AQUATIC FOODWEBS

IMPLEMENTATION OBJECTIVE

The implementation objective for Bay-Delta aquatic foodweb is to maintain, improve, or restore the amount of basic nutrients available to estuarine and river systems to provide a sustainable level of foodweb productivity.

INDICATORS

Nutrients are a necessary focus of restoration efforts, along with all other factors that may control the productivity of the restored ecological community. Many factors may prevent a community from utilizing all the nutrients available or the nutrient budget may not allow desirable species to compete effectively. Indicators must reflect both the availability of nutrients and their role in the foodweb.

Primary productivity can be monitored via traditional light and dark bottles.

On broader scales algal densities can reflect restoration of algal blooms in their historical sites and times. Data on organic carbon concentrations and fluxes would be of immense value in understanding estuarine productivity but are difficult to collect.

The importance of primary productivity on higher trophic levels cannot be easily assumed. Measurements of copepod egg sac characteristics, the size and number of larval Neomysis (or Acanthomysis) in the marsupium, and the gut fullness of selected fish species can provide evidence of the importance of trophic dynamics on higher trophic levels.

DATA REQUIREMENTS

Measurements of nutrient and trophic dynamics have been the subject of scientific study, but have not been used as a monitoring tool in this estuary. Studies have strongly suggested that certain species in certain places may be nutrient or food limited. These studies should guide the development of a monitoring program of the trophic dynamics.

NEXT STEPS

Species, times and areas must be identified wherein nutrient or food limitation may exert a controlling influence on ecosystem processes. IEP, USGS, and academic researchers have been the dominant students of this process and would be essential in the development of a meaningful monitoring program.

HABITAT ECOSYSTEM ELEMENTS

Protection, improvement and restoration of habitat involves identification of habitat attributes necessary for support of species dependent on the habitat, and the relation of habitats within the ecosystem. Table 2 was developed for use in identifying habitat indicators, and assesses which indicators apply to different scales of responses. The following are examples of indicators for the various categories in Table 2.

EXTENT

The total quantity of a habitat type can be linked to watershed functions or species population size, especially for special status or key (i.e. top predator) species. It is also important to ensure that the habitat type provides the functions within the landscape that it has historically provided. Possible examples are:

Riparian scrub, woodland and forest large enough to influence river temperature and provide temperature refugia sufficient in size, number and connectivity necessary for good survival for all life stages of native fish species dependent on cold water.

Enough backwater and tidal wetland areas within the downstream areas of major rivers and the Delta to provide good habitat for fry in years when they are moved out of the tributaries.

Hectares of riparian vegetation within floodplains with characteristics (i.e. tree density, tree basal area, shrub density, coarse woody debris) that increase roughness enough to slow floodwaters and reduce the erosional or flooding capability while still providing for successional processes.

QUALITY

Habitat quality should be included in any performance measures for individual habitat types. Indicators of quality are likely to also imply the necessity for a certain quantity of habitat in order to provide the necessary quality. Indices which measure maintenance of (1) spatial structure of the habitat; (2) successful use of the habitat for specific functions, such as nesting or cover and (3) the characteristic composition of the native plant and animal

	Scale	Extent	Quality	Connectivity	Diversity	Durability
HABITAT	Habitat	Acres, configuration. (For seasonal habitats consider acre-days and/or # days to qualify. In order to be counted acres must meet a threshold test related to quality and durability, therefore the # acres might be subdivided into high quality, transitional, etc.)	Structure: spatial structure, complexity, adjacent land use (e.g. shared perimeter w/Kmart parking lot). Also relates to connectivity, durability, = a stressor. Function: cooling, cover, other measures of performance. (develop #s by looking at reference sites) Composition: water quality, indicator species, guilds, predator/prey relationships	Seed source, source of faunal species to colonize	N/A (already incorporated in quality)	e.g. an average over a specified # of years, and/or a trajectory, as appropriate
	Geographic Zones	Summation of habitat acres for each habitat type[a], configuration (spatial distribution of patches)[a]	Meet threshold test for habitat quality for particular requirements of different life stages of species that move through corridors or between habitats[b]. (Most indicators already captured at habitat level)	Proportional representation of habitat types (like evenness, richness)[b]	Patch size, distance between patches, spatial connection to other habitats, connection to processes such as floodplain/river [a] Configuration among habitats [b]	e.g. an average over a specified # of years or trajectory for all (b)'s
	Landscape	Summation of zone #'s	ditto the zone scale			

(a) assesses whether restoration of each type of habitat within the zone is appropriate
(b) assesses whether restoration of composition, structure and function of separate types of habitats in relation to each other within a geographic zone is appropriate

Table 2. Derivation of Habitat Indicators

communities (including special status species and successional pattern);. If undisturbed (or little disturbed) reference sites are available, indices can be standardized to these sites. Examples are for Saline and Fresh emergent wetland and Riparian scrub, woodland and forest:

Emergent wetland with naturally sustained channel and pond features as complex and abundant as the historically natural condition.

Those measurable characteristics of native emergent vegetation such as species composition, density, cover, height and growth rate that: provide good quality cover, forage, nesting and perching conditions; discourage exotics and provide soil buildup where necessary.

Ratio of native to non-native vegetation in each stratum of a habitat type.

Instream and overhead riparian cover restored and maintained to levels preferred by salmonids, other fish species, birds and mammals utilizing such cover (as defined by the USFWS HSI for shaded riverine aquatic for the Sacramento River).

Riparian habitat successional processes dynamic enough to support both stable beaver populations and cottonwood recruitment and abundance as a natural percentage of riparian species.

Percent of floodplain riparian vegetation similar in species, abundance and age composition to remnant oak woodland patches in the Cosumnes watershed.

DURABILITY

Restoration is commonly carried out without enough thought about how well the habitats will persist into the future, given all the possible unforeseen (and foreseen) perturbations. Indices of success should measure and ensure that good quality habitats will result and continue to exist, and resist invasion by exotics. Sea level rise and new exotics are both examples of foreseen perturbations which are important to take into account. An example of an index relating to sea level rise could be:

Percent of acreage of each habitat type able to persist or move to higher elevation as sea level rises.

CONNECTIVITY AND DIVERSITY

It is important to identify performance measures or indices that reflect the fact that more than one habitat (defined as "type") are used by many species, for instance for nesting and foraging, and that habitat types are much more likely to provide the functions that they provided historically if they are embedded within a larger landscape with diverse habitats. For example, Saline emergent wetland and Fresh emergent wetland indices incorporating the value and importance of adjacent habitats:

Emergent wetland landward boundaries immediately adjacent to structurally complex riparian habitat and good quality grassland habitat adequate for wildlife to find protection from predation, flooding and other sources of disturbance and mortality, and to use for forage.

TIDAL PERENNIAL AQUATIC HABITAT

IMPLEMENTATION OBJECTIVE

The implementation objective for tidal perennial aquatic habitat is to increase the area of shallow-water and intertidal mudflat habitat to improve conditions that support increased primary and secondary productivity; provide rearing and foraging habitat, and escape cover for fish; and provide foraging and resting habitat, and escape cover for water birds.

INDICATORS

Physical indicators of tidal perennial aquatic habitat include: (1) location in the estuary, (2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota through time. Additional measures include observing the use of tidal areas for rearing and foraging by young fish, and foraging and resting use by water birds.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe tidal perennial aquatic habitats. Biological/ecological data include presence, distribution and abundance of aquatic foodweb organisms, fish species, plant species, and wildlife.

For comparative purposes, aerial photographs are needed on a recurrent interval of 2-3 years so that changes can be observed.

Newly restored areas will have no baseline and monitoring will be required to record recolonization by aquatic species.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

NONTIDAL PERENNIAL AQUATIC HABITAT

IMPLEMENTATION OBJECTIVE

The implementation objective is to increase the amount of nontidal perennial aquatic habitat in the Delta to provide improved foraging and resting habitat for water birds, particularly diving ducks, and help to restore and maintain the ecological health of the terrestrial and aquatic resources in and dependent on the Delta.

INDICATORS

Physical indicators of non-tidal perennial aquatic habitat include: (1) location in the system(2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota through time. Additional measures include observing the use of non-tidal areas for foraging and resting use by water birds.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe non-tidal perennial aquatic habitats. Biological/ecological data include presence, distribution and abundance of plant species and wildlife.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

DELTA SLOUGHS

IMPLEMENTATION OBJECTIVE

The implementation objective is to protect and improve existing tidal slough habitat and restore a portion of the historical Delta slough distribution. Sloughs will be restored within tidally influenced freshwater emergent wetlands, mudflats, and seasonal floodplains.

INDICATORS

Physical indicators of Delta slough health include: (1) location in the Delta, (2) areal extent (size), (3) quality, (4) type of adjacent habitat, and (5) flow velocities in open-ended slough and water quality in dead-end sloughs.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe Delta sloughs. Biological/ecological data include presence, distribution and abundance of aquatic foodweb organisms, fish species, plant species, and wildlife.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

MIDCHANNEL ISLANDS AND SHOALS

IMPLEMENTATION OBJECTIVE

The implementaion objective is to protect and enhance existing remnant channel islands in the Delta. Prioritize island restoration starting with those that have greatest chance to be maintained by restored streamflow patterns, hydraulic conditions, sediment transport, and other restored ecosystem processes.

INDICATORS

Physical indicators of mid-channel islands and shoals health include: (1) locations in the Delta, (2) areal extent (size), (3) quality, (4) type of adjacent habitat, and (5) stability or protection from wave erosion and other souces of degradation.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe mid-channel islands and shoals. Biological/ecological data include presence, distribution and abundance of aquatic foodweb organisms, fish species, plant species, and wildlife.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

SALINE EMERGENT WETLAND HABITAT

IMPLEMENTATION OBJECTIVE

The implementation objective is to increase the area of saline emergent wetlands, The increased wetlands area would provide high-quality habitat for waterfowl, shorebirds, and other associated wildlife; provide rearing habitat, foraging habitat, and escape cover for fish; and expand the populations and range of associates special-status and State- and federally listed plant and animal species.

INDICATORS

Physical indicators of saline emergent wetland habitat health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe saline emergent wetland habitat. Biological/ecological data include presence, distribution and abundance of aquatic foodweb organisms, fish species, plant species, and wildlife.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

FRESH EMERGENT WETLAND HABITAT

IMPLEMENTATION OBJECTIVE

The implementation objective is to protect and enhance existing wetlands by restoring tidally influenced freshwater emergent wetland in the Delta. This protected wetland would provide high-quality habitat for waterfowl, shorebirds, and other associated wildlife and rearing, foraging, and escape cover for fish. Populations and ranges of special-status and State and federally listed plant and animal species would be increased.

INDICATORS

Physical indicators of fresh emergent wetland habitat health include: (1) locations in the Delta, (2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe freshemergent wetland habitat. Biological/ecological data include presence, distribution and abundance of aquatic foodweb organisms, fish species, plant species, and wildlife.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

SEASONAL WETLANDS

IMPLEMENTATION OBJECTIVE

Restore and manage this habitat type in the Delta to help restore and maintain the ecological health of the aquatic resources in and dependent on the Delta; restore foodweb and floodplain processes; reduce the effects of contaminants and water management on the Delta's aquatic resources; and provide high-quality foraging and resting habitat for wintering waterfowl, greater sandhill cranes, and migratory and wintering shorebirds.

Indicators

Physical indicators of seasonal wetland health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

Data Requirements

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe seasonal wetlands. Biological/ecological data include presence, distribution and abundance of fish species, plant species, and wildlife.

Next Steps

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

Riparian and Riverine Aquatic Habitat

Implementation Objective

The implementation objective is to restore riparian scrub, woodland, and forest habitat along largely nonvegetated, riprapped banks of Delta island levees, the Sacramento and San Joaquin Rivers, and their major tributaries. Restored riparian habitat would provide shaded riverine aquatic cover for fish species, associated special-status species, and other wildlife.

Indicators

Physical indicators of riparian and riverine aquatic habitat health include: (1) locations in the Bay-Delta watershed, (2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

Data Requirements

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe riparian and riverine aquatic habitat. Biological/ecological data include presence, distribution and abundance of aquatic foodweb organisms, fish species, plant species, and wildlife.

Next Steps

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

Inland Dune Scrub

Implementation Objective

The implementation objective is to improve low- to moderate-quality Delta inland dune habitat to support special-status and animal species and other associated wildlife populations.

Indicators

Physical indicators of inland dune habitat health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe inland dune habitat. Biological/ecological data include presence, distribution and abundance of fish species, plant species, and wildlife.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

PERENNIAL GRASSLANDS

IMPLEMENTATION OBJECTIVE

The implementation objective is to preserve and restore perennial grassland habitat in conjunctions with restoration of wetland and riparian habitats in order to provide high-quality habitat conditions for associated special-status plant and wildlife populations.

INDICATORS

Physical indicators of perennial grassland health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe perennial grasslands. Biological/ecological data include presence, distribution and abundance of fish species, plant species, and wildlife.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

AGRICULTURAL LANDS

IMPLEMENTATION OBJECTIVE

The implementation objective is to co-manage agricultural upland and wetland habitat to provide wildlife forage and resting area habitat for wintering and migration waterfowl, shorebirds, and other associated wildlife in the Delta.

INDICATORS

Physical indicators of agricultural land health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat.

Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

DATA REQUIREMENTS

Two types of data are necessary: physical data and biological/ecological data. Physical data include areal extent, distribution and location, geomorphology, and other measures that describe agricultural lands. Biological/ecological data include presence, distribution and abundance of fish species, plant species, and wildlife.

NEXT STEPS

Baseline and historic data need to be developed for comparing historic conditions to the present. The present baseline is required for comparison with future changes. Much of this physical and biological/ecological data would have more utility if presented or developed as a geographic information system (GIS).

SPECIES ECOSYSTEM ELEMENTS

Indicators of the integrity of the native biotic community would include both indicators for individual species and for biological community. Special status species should be explicitly included. Indicators should address plants, birds, mammals, reptiles and amphibians and invertebrates (in addition to fish).

These are a landscape-level indicators. They will be the same at the zone level, except that all species may not apply to every zone.

For aquatic species indicators fall into three categories:

Abundances and distributions necessary for the long term survival of the population. For many native species these conditions are described in the Delta Native Fishes Recovery Plan of USFWS. Documents of CDFG, NMFS, and USFWS provide estimates of these numbers and distributions for many other species of interest. For species such as American shad and starry flounder, that use the estuary primarily for only part of their life cycle CALFED should be careful to set indicators only for the life stage affected by delta conditions.

For harvested species, harvest success must be a part of any restoration plan. Historical harvest data provide easy ways to quantify these targets.

For harvested species, public health concerns require that concentrations of contaminants be below levels that require health advisories to anglers.

Indicators for individual species will be compiled from appropriate documents.

A community index of relative rank abundance may be useful, or alternatively an index of biotic integrity where applicable in the upstream tributaries.

DELTA SMELT

IMPLEMENTATION OBJECTIVE

The implementation objective for delta smelt is to ensure the recovery of this species, which is State- and federally listed as threatened in order to contribute to overall species diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

INDICATORS

The indicator of delta smelt health is the degree to which its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period.

DATA REQUIREMENTS

Data are required for delta smelt distribution and abundance through time. The distribution data include the catches of delta smelt at ll stations in the north-central Delta, 5 stations in the Sacramento River, 4 stations in Montezuma Slough, and 15 stations in Suisun Bay. These data will be collected in the IEP's fall mid-water trawl (FMWT) survey. The abundance data include the number of fish captured in the FMWT.

NEXT STEPS

The FMWT is an ongoing IEP program.

Longfin Smelt

Implementation Objective

The implementation objective for longfin smelt is to ensure the recovery of this species of special concern in order to contribute to overall species diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

Indicators

The indicator of longfin smelt health is the degree to which its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1984 period.

Data Requirements

Data are required for longfinsmelt distribution and abundance through time. The distribution data include the catches of delta smelt at 3 stations in the north-central Delta, 5 stations in the Sacramento River, 4 stations in Montezuma Slough, 16 stations in Suisun Bay, 4 stations in San Pablo bay. These data will be collected in the IEP's fall mid-water trawl (FMWT) survey. The abundance data include the number of fish captured in the FMWT.

Next Steps

The FMWT is an ongoing IEP program.

Splittail

Implementation Objective

The implementation objective for Sacramento splittail is to assist in the recovery of this species, which is proposed for listing under the federal Endangered Species Act (ESA). Recovery of Sacramento splittail would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

Indicators

The indicator of splittail health is the degree to which its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1983 period.

Data Requirements

Data are required for splittail distribution and abundance through time. The distribution data include the catches of splittail in the FMWT, Bay Study otter trawl, and UCD Suisun Marsh otter trawl. The abundance data include the number of fish captured in the three studies.

Next Steps

The FMWT and Bay Study otter trawl are ongoing IEP programs. The Suisun Marsh otter trawl is conducted by U.C. Davis.

White and Green Sturgeon

Implementation Objective

The implementation objective for white sturgeon and green sturgeon is to restore the distribution and abundance of the white sturgeon to historical levels to support a sport fishery, and assist in the recovery of the green sturgeon, a California Department of Fish and Game species of special concern. Meeting this objective would contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

Indicators

The indicator of the health of green sturgeon is the degree to which population abundance meets or exceeds 1,000 fish over 39 inches total length.

The indicator of the health of white sturgeon is the degree to which population abundance meets population abundance is the 1960s.

Data Requirements

Green sturgeon abundance estimates are presently based on population estimation for white sturgeon. This is inadequate. A new monitoring program is required to independently estimate green sturgeon abundance. These abundance data need to be collected annually.

Next Steps

A new program and method to estimate green sturgeon abundance needs to be developed in conjunction with the Department of Fish and Game and the U.S. Fish and Wildlife Service (USFWS). This new program must be coordinated with the IEP's sturgeon project work team and the Comprehensive Assessment and Monitoring Program (CAMP) of the USFWS.

Chinook Salmon

Implementation Objective

The implementation objective for chinook salmon is to contribute to the recovery of the Sacramento winter-run chinook salmon, a species listed as endangered under the federal and California Endangered Species Acts (ESAs). Recovery of winter-run chinook salmon would ensure overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta. The objective is also to contribute to the restoration of Sacramento fall-run, spring-run, late-fall-run, and San Joaquin fall-run chinook salmon to support sport and viable commercial fisheries.

Indicators

The health of Central Valley chinook salmon will be determined primarily from the annual spawner estimates for each run in each ecological zone or ecological unit. Winter-run chinook salmon health will be determined by the degree to which annual escapement numbers compare to a draft restoration goal of 10,000 females. Spring-run chinook salmon health will be determined by the degree to which spawner estimates compare to 500 spawners each in Mill Creek and Deer Creek and an estimated 8,000 naturally spawning fish in all spring-run chinook habitat in the Sacramento Valley and its tributaries. The health of late-fall-run chinook salmon will be the degree to which annual spawner returns and number of harvested fish compare to the AFRP restoration target of 68,000 fish. The health of fall-run chinook salmon will be the degree to which annual spawner returns and numbers of harvested fish compare to the AFRP target of 750,000 fish.

Another indicator of population health is through use of the Cohort Replacement Rate (CRR) methodology. A CRR equal to 1.0 indicates a stable population, a CRR greater than 1.0 indicates an expanding population, and a CRR less that 1.0 indicates a declining population. CRR is used in conjunction with recent population estimates to determine health.

Data Requirements

Data requirements to determine the health of individual chinook salmon runs include:

- estimates of ocean commercial harvest,
- estimates of ocean recreational harvest,
- estimates of inland recreational harvest,
- counts of fish that return to the hatcheries, and
- estimates of naturally spawning fish.

Data are also needed to distinguish naturally spawning stocks from hatchery propagated fish, and data to distinguish between the various naturally spawning stocks. These latter data can be obtained from a comprehensive coded-wire tagging program, constant fractional marking programs, and from genetic analyses.

Next Steps

A comprehensive coded-wire tagging program should be developed and implemented to provide a basis for future determination of the health of chinook salmon runs. Additional research into genetic analysis techniques to separate stocks should be implemented and completed.

STEELHEAD TROUT

IMPLEMENTATION OBJECTIVE

The implementation objective for steelhead trout is to achieve naturally spawning populations of sufficient size to support inland recreational fishing and fully use existing and restored habitat areas. Meeting this objective would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

INDICATOR

DATA REQUIREMENTS

Data requirements to determine the health of steehead include:

- estimates of inland recreational harvest,
- counts of fish that return to the hatcheries, and
- estimates of naturally spawning fish.

Data are also needed to distinguish naturally spawning stocks from hatchery propagated fish, These latter data can be obtained from comprehensive coded-wire tagging programs, constant fractional marking programs, and from genetic analyses.

NEXT STEPS

A comprehensive coded-wire tagging program should be developed and implemented to provide a basis for future determination of the health of steelhead. Additional research into genetic analysis techniques to separate stocks should be implemented and completed.

STRIPED BASS

IMPLEMENTATION OBJECTIVE

The implementation objective for striped bass is to restore its population levels to those of the 1960s to contribute to a recreational fishery in the Bay-Delta. Increased population levels of striped bass would reduce conflict between the need for its protection and other beneficial uses of water in the Bay-Delta.

INDICATORS

The indicator of health of striped bass is the degree to which the annual population estimate compares to the population level present in the 1960s of between 2 million and 3 million adult fish.

DATA REQUIREMENTS

The data required to determine health of striped bass is obtained from an annual marking and recovery program conducted by the Department of Fish and Game.

NEXT STEPS

This striped bass monitoring program is an ongoing program by the Department of Fish and Game.

AMERICAN SHAD

IMPLEMENTATION OBJECTIVE

The implementation objective for American shad is to maintain naturally spawning populations that support sport fisheries similar to those observed in the 1960s and 1970s to contribute to the recreational use of the Bay-Delta. Meeting this objective would reduce conflict between the need for protection of this species and other beneficial uses of water in the Bay-Delta.

INDICATORS

The indicator of health of American shad is the degree to which juvenile shad abundance as determined by the IEP FMWT compares to earlier abundance indices. The baseline index for this comparison is 3,212 juvenile American shad.

DATA REQUIREMENTS

American shad abundance index is annually determined from data collected at about 90 sampling sites throughout San Pablo Bay, Suisun Bay,k and the Sacramento-San Joaquin Delta. Data include counts or estimates by subsampling of the number of American shad per trawl, length measurements, calculation of abundance index based on trawl catches and water volume samples. Monthly abundance indices are summed to generate an annual abundance index.

NEXT STEPS

Collection of young American shad data is an ongoing program.

RESIDENT FISH SPECIES

IMPLEMENTATION OBJECTIVE

The implementation objective for resident fish species is to maintain and restore the distribution and abundance of resident native fish species, such as Sacramento blackfish, hardhead, tule perch, and Sacramento perch, and non-native species, such as white catfish, largemouth bass, and threadfin shad, to support a sport fishery and healthy forage populations.

INDICATORS

Annual adult and juvenile fish population indices provide the best assessment of health for resident fish species.

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

MARINE/ESTUARINE FISHES AND LARGE INVERTEBRATES

IMPLEMENTATION OBJECTIVE

The implementation objective for marine and estuarine fishes and large invertebrates is to maintain, improve, and restore populations of these species to levels that existed in the early 1980s. Meeting this objective would contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

INDICATORS

[In progress.]

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

BAY-DELTA AQUATIC FOODWEB ORGANISMS

IMPLEMENTATION OBJECTIVE

The implementation objective for Bay-Delta aquatic foodweb organisms is to restore the estuary's once productive food base of aquatic algae, organic matter, microbes, and zooplankton.

INDICATORS

[In progress.]

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

WESTERN SPADEFOOT AND CALIFORNIA TIGER SALAMANDER

IMPLEMENTATION OBJECTIVE

The implementation objective for marine and estuarine fishes and large invertebrates is to maintain, improve, and restore populations of these species to levels that existed in the early 1980s. Meeting this objective would contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of water in the Bay-Delta.

INDICATORS

[In progress.]

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

CALIFORNIA RED-LEGGED FROG

IMPLEMENTATION OBJECTIVE

The implementation objective for the California red-legged frog is to assist in the recovery of this federally listed threatened species. Recovery of the California red-legged frog would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

INDICATORS

[In progress.]

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

GIANT GARTER SNAKE AND WESTERN POND TURTLE

IMPLEMENTATION OBJECTIVE

The implementation objective for the giant garter snake, a federally listed threatened species, and western pond turtle, a species of special concern, is to assist in their recovery. Meeting this objective would contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.

INDICATORS

[In progress.]

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

SWAINSON'S HAWK

IMPLEMENTATION OBJECTIVE

The implementation objective for the Swainson's hawk is to assist in the recovery of this State-listed threatened species. Recovery of Swainson's hawk would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

INDICATORS

[In progress.]

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

CALIFORNIA CLAPPER RAIL

IMPLEMENTATION OBJECTIVE

The implementation objective for the California clapper rail is to assist in the recovery of this State- and federally listed endangered species. Recovery of the clapper rail would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

INDICATORS

[In progress.]

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

California Black Rail

Implementation Objective

The implementation objective for the California black rail is to assist in the recovery of this State-listed threatened species. Recovery of the California black rail would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Greater Sandhill Crane

Implementation Objective

The implementation objective for the greater sandhill crane is to assist in the recovery of this State-listed threatened species. Recovery of the greater sandhill crane would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Western Yellow-Billed Cuckoo

Implementation Objective

The implementation objective for the western yellow-billed cuckoo is to assist in the recovery of this State-listed endangered species. Recovery of the western yellow-billed cuckoo would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Bank Swallow

Implementation Objective

The implementation objective for the bank swallow is to assist in the recovery of this State-listed threatened species. Recovery of the bank swallow would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Suisun Song Sparrow

Implementation Objective

The implementation objective for the Suisun song sparrow is to assist in the recovery of this State- and federally listed endangered species. Recovery of the Suisun song sparrow would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Salt Marsh Harvest Mouse

Implementation Objective

The implementation objective for the salt marsh harvest mouse is to assist in the recovery of this State- and federally listed endangered species. Recovery of the salt marsh harvest mouse would contribute to overall species diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Riparian Brush Rabbit

Implementation Objective

The implementation objective for the riparian brush rabbit is to assist in the recovery of this State-listed endangered species in the Bay-Delta. Recovery of the riparian brush rabbit would contribute to overall species richness and diversity and reduce conflict between the need for its protection and other beneficial uses of land and water in the Bay-Delta.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Waterfowl

Implementation Objective

The implementation objective for waterfowl is to maintain healthy populations at levels that can support both consumptive and nonconsumptive uses.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Upland Game

Implementation Objective

The implementation objective for upland game is to maintain healthy populations at levels that can support both consumptive and nonconsumptive uses.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

Neotropical Migratory Bird Guild

Implementation Objective

The implementation objective for the neotropical migratory bird guild is to maintain healthy populations. Healthy populations of neotropical migratory birds would contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land and water in the Bay-Delta.

Indicators

[In progress.]

Data Requirements

[In progress.]

Next Steps

[In progress.]

LANGE'S METALMARK, DELTA GREEN GROUND BEETLE, AND VALLEY ELDERBERRY LONGHORN BEETLE

IMPLEMENTATION OBJECTIVE

The implementation objective is to assist in maintaining populations of the Lange's metalmark, a federally listed endangered species, by increasing its abundance, and assist in the recovery of the delta green ground beetle and Valley elderberry longhorn beetle, both federally listed endangered species, by increasing their populations and abundance. Meeting this objective would contribute to overall species richness and diversity and reduce conflict between the need for their protection and other beneficial uses of land water in the Bay-Delta.

INDICATORS

[In progress.]

DATA REQUIREMENTS

[In progress.]

NEXT STEPS

[In progress.]

Recommend deleting stressors.

STRESSOR ECOSYSTEM ELEMENTS

In general, stressors are structures, activities and other results of human activities that are expected to reduce the effectiveness of restoration activities by interfering with more natural structures and processes. Thus, the level of control needed on stressors will vary with location and the type of restoration activity they affect.

WATER DIVERSIONS

IMPLEMENTATION OBJECTIVE

The implementation objective is to reduce entrainment of juvenile fish into water diversions to increase survival and population abundance to levels that contribute to the overall health of the Delta and reduce conflicts for other beneficial uses of land and water.

INDICATORS

Diversions and associated structures represent another type of structure that interferes with fish passage. The same indicators would be appropriate in both cases.

Effects of flow variations due to the operation of water projects should be reflected in the indicators associated with streamflow, temperature, and natural hydrologic regime.

DATA REQUIREMENTS

NEXT STEPS

DAMS, RESERVOIRS, WEIRS, AND OTHER HUMAN-MADE STRUCTURES

IMPLEMENTATION OBJECTIVE

The implementation objective for dams, reservoirs, weirs, and other human-made structures is to increase the connection of upstream spawning and rearing habitat with the mainstem rivers in the Sacramento-San Joaquin basin to increase success of adult spawners and survival of juvenile downstream migrants.

INDICATORS

Monitoring associated with this implementation objective will have to be very site-specific, but appropriate indicators would be average delay of upstream migration (measured by densities below structure compared to densities at unimpeded sites) and survival rates of outmigrating young (compared to survival rates on average at unimpeded sites. In both cases the appropriate level of indicator would be to have no impact of the structure (indicator at site = indicator at unimpaired).

Data Requirements

Next Steps

Levees, Bridges and Bank Protection

Implementation Objective

The implementation objective for levees, bridges, and bank protection is to reestablish or reactivate natural landform processes leveed channel reaches to allow for periodic inundation of the natural floodplain.

Indicators

Hydrological connections of river channels to their natural floodplains has been reduced, to the detriment of several ecological processes. Site specific features will be principal determinants of the ability and value of re-establishing floodplain connections. In some areas artificial restrictions have produced undesirable alterations in the velocities and erosive patterns in the river channel.

Success in re-establishing floodplain connections is reflected in indicators of streamflow patterns (I.1) and Geomorphology (I.4).

Current velocities and associated disruptive patterns of erosion are discussed under Current Velocities (I.9).

Data Requirements

Next Steps

Dredging and Sediment Disposal

Implementation Objective

The implementation objective for dredging and sediment disposal is to reduce loss and degradation of aquatic habitat and vegetated berm islands caused by dredging activities and reduce impacts of dredging activities on aquatic resources during critical spawning and rearing periods and in sensitive areas. Meeting this objective would help to protect, restore, and maintain the health of aquatic resources in and dependent on the Delta.

Indicators

Dredging impacts extend throughout the watershed. In upstream areas dredging may reduce the success of other efforts to restore gravel cleansing (I.7). In downstream areas dredging can reduce the effectiveness of actions to improve the stability of channel morphometry (I.10). On the other hand, changes in dredging operations may improve the ability to restore sediment and nutrient budgets for the estuary (I.1 and I.3) and assist in gravel transport and recruitment (I.6 and I.7). Dredge spoils may also provide the raw material for the restoration of several types of aquatic habitats.

Monitoring of dredging activities in each area will be a critical element in determining the determinants of success for various restoration activities. Areas of dredging activity where the indicators of restoration activities are not as effective as elsewhere would be the indicator of a need to modify dredging actions. Separate indicators for dredging impacts are probably not needed and the appropriate level of control on dredging activities will be strongly dependent on their local impacts on achieving other goals.

Data Requirements

Next Steps

Gravel Mining

Implementation Objective

The implementation objective is to reduce the adverse effects of instream gravel mining to improve gravel recruitment, cleansing, and transport.

INDICATORS

This stressor will be completely reflected in the indicators associated with gravel process identified under ecological processes (I.6 and I.7).

DATA REQUIREMENTS

NEXT STEPS

INVASIVE AQUATIC PLANTS

IMPLEMENTATION OBJECTIVE

The implementation objective for invasive aquatic plants is to reduce the adverse effects of these species on native plants to increase and maintain the productivity of the aquatic foodweb, preserve suitable fish habitat structure, and provide quality habitat conditions for native submergent and emergent plants.

INDICATORS

Percent of acres or kilometers of edge of aquatic habitats suitable for suitable for valued native plants that are occupied or affected by harmful exotic species.

DATA REQUIREMENTS

NEXT STEPS

INVASIVE AQUATIC ORGANISMS

IMPLEMENTATION OBJECTIVE

The implementation objective for invasive aquatic organisms is to reduce introductions of non-native aquatic organisms to protect and provide sustainable populations of native species.

INDICATORS

Number of new species established each year in the estuary will be the best indicator of success in controlling the rate of invasion. Currently this rate is about one per 12 weeks (Carlton and Cohen) while the desirable level is clearly zero. Control of the effects of introduced species will be reflected in the degree to which species of concern are recovered.

DATA REQUIREMENTS

NEXT STEPS

INVASIVE RIPARIAN AND SALT MARSH PLANTS

IMPLEMENTATION OBJECTIVE

The implementation objective for invasive riparian and salt marsh plants is to reduce populations of invasive non-native tree and shrub species that compete with native riparian vegetation. Reducing invasive riparian and salt marsh plants would help to establish and support sustainable native vegetation communities.

INDICATORS

Percent of acres or kilometers of edge of aquatic habitats suitable for suitable for valued native plants that are occupied or affected by harmful exotic species.

DATA REQUIREMENTS

NEXT STEPS

NON-NATIVE WILDLIFE

IMPLEMENTATION OBJECTIVE

The implementation objective for non-native wildlife is to reduce the abundance of non-native wildlife species to maintain and expand the diversity or abundance of native species or the ecological stability of native habitats.

INDICATORS

Control of the effects of introduced species will be reflected in the degree to which species of concern are recovered.

DATA REQUIREMENTS

NEXT STEPS

PREDATION AND COMPETITION

IMPLEMENTATION OBJECTIVE

The implementation objective for predation and competition is to reduce the loss of juvenile anadromous and resident fish and other aquatic organisms from unnatural levels of predation to contribute to the restoration of important species.

INDICATORS

DATA REQUIREMENTS

NEXT STEPS

CONTAMINANTS

IMPLEMENTATION OBJECTIVE

The implementation objective is to reduce concentrations and loading of contaminants in the aquatic environment and the subsequent bioaccumulation by aquatic species. Reducing contaminants would increase survival of aquatic species and eliminate public health concerns resulting from accumulation of toxins in tissues.

INDICATORS

This stressor is easily quantified and, unlike most other stressors, requires a separate set of indicators because it is expected to have broad and direct ecosystem impacts.

Indicators associated with direct ecosystem impacts would be associated with general measures of aquatic toxicity as through standard bioassay techniques. Separate indicators for individual families of contaminants may be desirable but may not be necessary for ecosystem restoration monitoring. Suitable quantification would likely be zero toxicity.

Indicators associated with indirect ecosystem functions will need to focus on concentrations of contaminants in selected organs of key species. Histopathological analysis may be a cheaper alternative for monitoring indirect levels of impacts of contaminants.

Indicators associated with public health concerns would be the number of species for which public health warnings are issued. Suitable quantification goals are probably zero.

DATA REQUIREMENTS

NEXT STEPS

FIRE

IMPLEMENTATION OBJECTIVE

The implementation objective is to reduce the acreage and frequency of catastrophic wildfires to reduce their adverse effects on fish and wildlife and their habitats.

INDICATORS

Wildfire control and associated activities are likely to affect various parameters of streamflow and gravel cleaning and sediment transport. No separate indicator seems necessary.

DATA REQUIREMENTS

NEXT STEPS

FISH AND WILDLIFE HARVEST

IMPLEMENTATION OBJECTIVE

The implementation objective for harvest is to regulate harvest of fish and wildlife to the extent necessary to avoid impairing the reproductive capacity of the population in relation to available habitat.

INDICATORS

DATA REQUIREMENTS

NEXT STEPS

ARTIFICIAL FISH PROPAGATION

IMPLEMENTATION OBJECTIVE

The implementation objective for artificial propagation of fish is to reduce the potentially adverse effects of stocking artificially produced fish throughout Central Valley rivers and streams. Reducing these effects would increase the survival of naturally produced fish, contribute to long-term restoration goals, and maintain the genetic diversity of naturally producing populations of chinook salmon and steelhead populations.

INDICATORS

DATA REQUIREMENTS

NEXT STEPS

DISTURBANCE

IMPLEMENTATION OBJECTIVE

The implementation objective for disturbance is to reduce human activities that adversely affect wildlife behavior or cause habitat destruction. Reducing these activities would increase reproductive success and contribute to restoration of important species.

INDICATORS

DATA REQUIREMENTS

TABLE 2. List of Ecosystem Elements and Their Respective Indicator.

Ecosystem Element	Indicator
Ecological Processes	
Central Valley Streamflows	Indicators for Central Valley streamflows will include a comparison of actual streamflows to a preferred hydrograph that integrates the ecological functions supported by streamflow. The role of streamflow in maintaining aquatic and riparian habitats will be reflected in the interaction of streamflow with geometry to produce aquatic habitats. An additional function of streamflow is the oxygenation of redds, principally of concern in lower elevations. The habitat requirements of fish, wildlife, and plant populations within each ecological zone or unit will provide the necessary quantification. ■ Upstream. The presence, distribution, and quality of riffle-pool-run sequences will be appropriate for upstream sites. These sequences can only exist where streamflows are high and variable enough to mobilize the bedload and support erosional and depositional processes. For particular species or communities, the Instream Flow Incremental Methodology (IFIM) might be used to quantitatively describe different velocity-based habitats. ■ Lower elevation streams. Meander lengths and transects will reflect the role of streamflow alterations in lower reaches of streams and rivers. Maintenance of local meander processes will integrate both bathymetric and flow changes. For particular species or communities, the IFIM might be used to quantitatively describe different velocity-based habitats with particular river reaches. ■ Oxygenation of redds is directly measurable in the field. This indicator would be well-measured also by the successful emergence of fry. ■ Lower rivers and delta. Hectares of flooded vegetation, wetted perimeter, and bathymetric diversity would all reflect the interaction streamflow and physical changes in supporting habitats within the delta. Salinity regimes in the lower delta and upper bay (measured by X2 during the germination season) will be a necessary indicator of habitat suitability for particular habitats.

Natural Sediment Supply	The sediment supply objective is addresses the restoration of stream channel meanders, formation of shallow habitats in depositional areas, and to provide for nutrient transport. Indicators therefore fall into three categories: ■ Restoration of stream meanders in lower elevation streams. Sinuosity of stream channel measured by kilometers of river channel per standardized river kilometer will indicate success of restoration of meander processes. If erodible banks abut the stream channel, sediment supply is unlikely to limit meander processes. ■ Formation of shallow areas. Accretion or erosion of particular sites would indicate whether the sediment budget was adequate to support restored habitats. Measures of sediment loads at each confluence would provide more information than needed for this indicator but would permit construction of a sediment budget that would be useful generally. Current velocities in the upstream reaches and wind-generated resuspension of sediments in San Francisco Bay are expected to supply adequate sediment loads to rebuild wetland habitats in either area. Sediment limitation is most likely to affect the success of wetland construction within the delta. ■ Nutrient supply. Currently, evidence suggests that the ecosystem is seldom limited by sediment derived nutrient transport rates. However, a more productive ecosystem might become nutrient limited. Algal growth rates in bottles with and without augmented nutrient levels would permit monitoring of this potential problem. This objective aims to ensure adequate abundance of good gravel conditions to support the spawning of anadromous fish. In addition, support of riparian succession and the maintenance of various instream habitats is also supported. The principal intent of this objective will be reflected in the abundance of good spawning sites, measured through stream surveys of, perhaps, wintertime aerial photographs. This indicator is closely linked to the number of adults returning to spawn and their ability to use all spawning habitat. Redd superimposition and crowding at obstructions would be two supplementary indicators to assess whether gravel recruitment was providing the intended level of ecosystem support. As with nutrient supply, this parameter may become more important as ecosystem restoration leads to increased productivity. The characteristics of suitable spawning gravels are supported by most of the significant processes associated with bedload movement in a river. Suitable sizes of gravel exposed at the surface, without armoring or excessive silt. These conditions can only persist the recruitment of gravel is adequate to balance loss, flows and sediment loads produce a washing away of fine sediments from the gravel and disturbance flows happen regularly enough to prevent armoring of the gravel.

Stream Meander Corridors	Dynamic sediment balances and the consequent creation and movement of habitat in river meanders would be monitored through aerial photographs and stream transects. The successful incorporation of successional stages would be determined through the characteristic percentages of each stage. Successful support of seral stages would be of particular interest at several scales of analysis.
Natural Floodplains and Flood Processes	Seasonal inundation is currently a phenomenon associated with disaster conditions. Construction of seasonally floodable areas would integrate leveed areas with some broader streamside processes and provide the benefits of bypasses to areas subject to flooding. Indicators would include both reduced incidence of flooding protected areas at given levels of riverflow and number of days of inundation of specified areas at the 2 and 10 year flood flows. Prolongation of flood flows would be reflected by period of inundation of floodplains, standardized to the 2- and 10-year flood flow events. Restoration of floodplain functions would be expected to lower the peak and extend the duration of outflow hydrographs. This indicator would be readily interpreted from river flow and delta outflow estimates. Reductions in flow velocity would largely be a necessary correlate of extended flood flow duration, but measures of sediment transport and retention would be reflective of these actions. On a smaller scale, within stream channels, the reduction of scour due to high flow velocity would be well reflected in the below-water angle of channel sides. Reduction of this angle is a necessary pre-condition for the creation and stabilization of several habitats discussed in III. The angle representing stability will depend on site-specific characteristics, but in all cases this indicator should be scaled by its degree of conformance to a stable angle.
Central Valley Stream Temperatures	Temperature needs of life history stages of various salmonids are well studied. The percentage of time and area within various watershed zones when temperatures (°C) are suitable for the anadromous fish in that zone is a straightforward measure of the success of this objective. As with sediment supply and streamflow, the indicators associated with this objective are probably among the best to monitor ecosystem restoration success over large geographic areas.

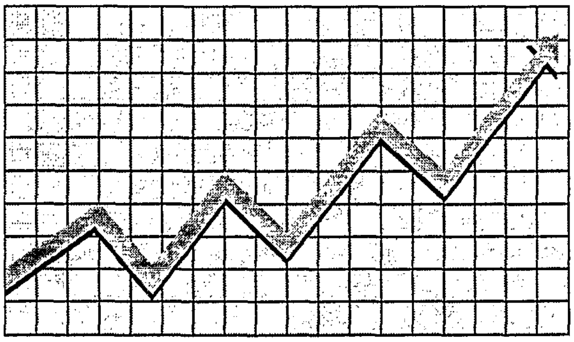
Bay-Delta Hydraulics	Migratory cues for anadromous fish and transport of newly spawned eggs and larvae from spawning grounds to nursery areas are expected to improve by returning to a more natural hydrologic regime. Indicators therefore fall into two categories: ■ Smolt success in reaching Chipps Island from each entry point into the delta, Additional information from radio-tagged wild fish would be extremely useful. Successful migration of adults would be another important indicator of successful restoration of migratory cues. ■ Distribution of ichthyoplankton such that highest concentrations occur in suitable habitats.
Bay-Delta Aquatic Foodweb	Nutrients are a necessary focus of restoration efforts, along with all other factors that may control the productivity of the restored ecological community. Many factors may prevent a community from utilizing all the nutrients available or the nutrient budget may not allow desirable species to compete effectively. Indicators must reflect both the availability of nutrients and their role in the foodweb. Primary productivity can be monitored via traditional light and dark bottles. On broader scales algal densities can reflect restoration of algal blooms in their historical sites and times. Data on organic carbon concentrations and fluxes would be of immense value in understanding estuarine productivity but are difficult to collect. The importance of primary productivity on higher trophic levels cannot be easily assumed. Measurements of copepod egg sac characteristics, the size and number of larval Neomysis (or Acanthomysis) in the marsupium, and the gut fullness of selected fish species can provide evidence of the importance of trophic dynamics on higher trophic levels.
Upper Watershed Processes - Fire and Erosion	
Habitats	
Tidal Perennial Aquatic	Physical indicators of tidal perennial aquatic habitat include: (1) location in the estuary, (2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota through time. Additional measures include observing the use of tidal areas for rearing and foraging by young fish, and foraging and resting use by water birds.

Nontidal Perennial Aquatic	Physical indicators of non-tidal perennial aquatic habitat include: (1) location in the system(2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota through time. Additional measures include observing the use of non-tidal areas for foraging and resting use by water birds.
Delta Sloughs	Physical indicators of Delta slough health include: (1) location in the Delta, (2) areal extent (size), (3) quality, (4) type of adjacent habitat, and (5) flow velocities in open-ended slough and water quality in dead-end sloughs. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.
Mid-channel Islands and Shoals	Physical indicators of mid-channel islands and shoals health include: (1) locations in the Delta, (2) areal extent (size), (3) quality, (4) type of adjacent habitat, and (5) stability or protection from wave erosion and other souces of degradation. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.
Saline Emergent Wetland	Physical indicators of saline emergent wetland habitat health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.
Fresh Emergent Wetland	Physical indicators of fresh emergent wetland habitat health include: (1) locations in the Delta, (2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.
Seasonal Wetlands	Physical indicators of seasonal wetland health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.

Riparian and Riverine Aquatic	Physical indicators of riparian and riverine aquatic habitat health include: (1) locations in the Bay-Delta watershed, (2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.
Inland Dune Scrub	Physical indicators of inland dune habitat health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.
Perennial Grassland	Physical indicators of perennial grassland health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.
Agricultural Lands	Physical indicators of agricultural land health include: (1) locations in the Delta and Bay (2) areal extent (size), (3) quality, and (4) type of adjacent habitat. Biological/ecological indicators include the measures of baseline biota (diversity and abundance of plants and animals) and changes in biota including vegetation through time.
Species and Species Groups	
Delta Smelt	The indicator of delta smelt health is the degree to which its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1981 period.
Longfin Smelt	The indicator of longfin smelt health is the degree to which its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1984 period.
Splittail	The indicator of splittail health is the degree to which its population dynamics and distribution pattern within the estuary are similar to those that existed in the 1967-1983 period.
White and Green Sturgeon	The indicator of the health of green sturgeon is the degree to which population abundance meets or exceeds 1,000 fish over 39 inches total length. The indicator of the health of white sturgeon is the degree to which population abundance meets population abundance is the 1960s.

Chinook Salmon	The health of Central Valley chinook salmon will be determined primarily from the annual spawner estimates for each run in each ecological zone or ecological unit. Winter-run chinook salmon health will be determined by the degree to which annual escapement numbers compare to a draft restoration goal of 10,000 females. Spring-run chinook salmon health will be determined by the degree to which spawner estimates compare to 500 spawners each in Mill Creek and Deer Creek and an estimated 8,000 naturally spawning fish in all spring-run chinook habitat in the Sacramento Valley and its tributaries. The health of late-fall-run chinook salmon will be the degree to which annual spawner returns and number of harvested fish compare to the AFRP restoration target of 68,000 fish. The health of fall-run chinook salmon will be the degree to which annual spawner returns and numbers of harvested fish compare to the AFRP target of 750,000 fish. Another indicator of population health is through use of the Cohort Replacement Rate (CRR) methodology. A CRR equal to 1.0 indicates a stable population, a CRR greater than 1.0 indicates an expanding population, and a CRR less that 1.0 indicates a declining population. CRR is used in conjunction with recent population estimates to determine health.
Steelhead Trout	
Striped Bass	The indicator of health of striped bass is the degree to which the annual population estimate compares to the population level present in the 1960s of between 2 million and 3 million adult fish.
American Shad	The indicator of health of American shad is the degree to which juvenile shad abundance as determined by the IEP FMWT compares to earlier abundance indices. The baseline index for this comparison is 3,212 juvenile American shad.
Resident Fish Species	
Marine/Estuarine Fishes and Large Invertebrates	
Bay-Delta Aquatic Foodweb Organisms	
Western Spadefoot and California Tiger Salamander	
California Red-legged Frog	
Giant Garter Snake and Western Pond Turtle	

Swainson's Hawk	
California Clapper Rail	
California Black Rail	
Greater Sandhill Crane	
Western Yellow-billed Cuckoo	
Bank Swallow	
Suisun Song Sparrow	
Salt Marsh Harvest Mouse	
Riparian Brush Rabbit	
Shorebird and Wading Bird Guild	
Waterfowl	
Upland Game	
Neotropical Migratory Bird Guild	
Lange's Metalmark, Delta Green Ground Beetle, and Valley Elderberry Longhorn Beetle	



INTRODUCTION

Adaptive management is an important component of the implementation strategy of the long-term, comprehensive plan to restore ecosystem health in the Bay-Delta system. Adaptive management is an interactive process, which recognizes the inherent uncertainty of ecosystem management caused by a lack of conclusive information about cause and effect relationships, ecosystem complexity that is difficult to understand, or questions about how much restoration is needed to provide for a "healthy" ecosystem. This approach confirms the results of successful restoration actions and redirects the type and magnitude of restoration plan actions in response to increasing knowledge. An effective adaptive management program requires the continuous examination of monitoring data relevant to the restoration plan's objectives and targets. This section of the ERPP identified and briefly the components of a monitoring program which will provide the data and analysis to support the Restoration Program's adaptive management approach. The monitoring program described here will eventually be combined and integrated with monitoring and assessment activities associated with CALFED's other core programs.

Two general types of monitoring will be required to support the restoration program. First, system-wide monitoring of all important components and processes of the ecosystem will be required to evaluate the overall success of actions, and factors influencing that success. We refer to this in the ERPP as "General Ecosystem Monitoring". This type of monitoring is most closely associated with the programmatic objectives, indicators, and targets of the ERPP. The second type of monitoring is referred to as "Action-Specific Monitoring". This type of monitoring is associated with the detailed evaluation of individual restoration actions or projects (large and small scale). Action-specific monitoring plans will be required for all restoration actions and will be project specific in design.

Finally, we have included a "Monitoring Implementation Strategy" which describes how the monitoring plan will be further developed and accomplished through coordination with various existing programs.

GENERAL ECOSYSTEM MONITORING

The general ecosystem monitoring program is designed to accomplish three major objectives. They are:

1) Measure the response of the Bay-Delta system to restoration actions in terms of the specific ecosystem implementation objectives, indicators, and targets identified in the ERPP.

   The ERPP contains a list of "indicators" and "targets" associated with its ecosystem implementation objectives. Targets are specifically defined response levels of ecosystem indicators (e.g. a specific species/life stage abundance levels, stressor levels, or amounts of habitat types). The primary function of the monitoring program is to measure and report the levels of these indicators, so that progress towards the desired level of ecosystem health is known.

2) Measure a suite of basic ecosystem variables that is geographically and ecologically broad

enough to support the interpretation of observed response or lack of response of the system to specific actions implemented under the ERPP.

Adaptive management requires that the mechanisms behind observed ecosystem responses are understood. Without this understanding it may not be possible to efficiently and confidently redirect restoration actions. Therefore, another function of the monitoring program is to measure all (to the extent possible) ecosystem variables that are likely to significantly affect the response of the indicator characteristics identified in the ERPP. In some cases, information from the adjacent ocean and above system dams will be obtained and used for this interpretive process

3) Integrate the analysis and reporting of system monitoring data.

Ecosystem and adaptive management approaches to Bay-Delta system restoration requires that monitoring data are analyzed and reported in an integrated fashion. Existing monitoring is conducted by many separate entities, and this will likely remain true as restoration activities proceeds. These entities will cooperate to bring all relevant data into a data base system to facilitate integrated analysis. As needed, technical teams will be established to supplement existing analysis and reporting efforts.

It is not necessary to establish another new monitoring program for the Bay-Delta system. Rather, cooperation among existing programs will be developed to ensure that the necessary ecosystem monitoring data is collected, and that cooperative processes are in place to utilize the data for decision making. The proposed monitoring program incorporates elements from the San Francisco Estuary Project's Regional Monitoring Program, the Interagency Ecological Program, the recently developed CVPIA Comprehensive Assessment and Monitoring Program and other programs. Cooperation from the respective programs will be encouraged to address the refinements and enhancements of existing programs which may be needed to meet the specific informational requirements of an adaptive management approach to Bay-Delta system restoration.

The general ecosystem monitoring program is subdivided into a series components ("sub-programs") based on ecological and geographic characteristics. A brief description of each component or sub program follows. More detailed descriptions of each of these sub-programs are provided in Appendix __. Collectively the sub-programs address monitoring for a wide range of ecosystem processes, functions, trophic levels and habitat types.

The sub-program descriptions in Appendix __ include lists of "Key Focused Research Topics". In some cases these lists address cases where the ERPP identifies a key ecosystem indicator (e.g. the abundance level of a particular fish species/life stage) for which there is presently no adequate method of measurement, and focused research and pilot studies are needed to develop appropriate measures (indices) of abundance, and effective sampling and sample processing methods. Also listed, are subject areas where focused research is needed to advance understanding of the ecosystem to the point where specific restoration actions can be confidently proposed. In some cases these research topics are already being pursued, but are listed to emphasize support for their completion. The Focused Research section of the ERPP Volume III provides a general description of these and other proposed research topics.

River and Estuarine Flow Monitoring Sub-program

The Ecosystem Restoration Program will be supported by a comprehensive system of flow monitoring in mainstem rivers, tributaries, and key Delta channels for two reasons. First, flow monitoring is required to assess progress towards achieving the Restoration Program's objectives, indicators and targets that specifically address flow conditions in the Delta and in its tributaries. Fish transport flows and entrapment zone location are examples of these flow-related objectives and targets. Flow monitoring is also required, because flow is an important ecosystem variable that can influence the performance of restoration actions implemented to achieve non-flow objectives and targets. For example, river morphology and riparian habitat responses to levee set-backs will depend in part on flow conditions.

Currently, the releases from system reservoirs is continuously monitored and reported. Most tributary streams in the drainage have at least one flow measurement site. Flow measurement stations are taken at key locations on the mainstem Sacramento and San Joaquin rivers. Finally, major advances in Delta channel flow measurement have been made in recent years. The network of Ultrasonic Velocity Meter (UVM) stations established in the Delta by USGS now provide continuous tidal and net flow in many key Delta channels, and provide more accurate estimates of a key variable, Delta outflow.

Generally, existing flow monitoring programs provide sufficient information to adaptively manage the Restoration Program. Additional site specific monitoring sites may be added with reasonable effort.

Cooperation with water project operators and the USGS will continue to ensure that existing flow monitoring information important to restoration management continues, and to facilitate necessary flow monitoring system enhancements.

SYSTEM-WIDE BASIC WATER QUALITY MONITORING SUB-PROGRAM

The monitoring program must provide basic water quality information from the entire Bay-Delta system. Basic water quality parameters such as temperature, salinity, and chlorophyll concentration define the fundamental condition of aquatic habitat in the system and are essential for interpreting all other aquatic biological monitoring data. Some restoration implementation objectives and targets specifically address basic water quality conditions. For example, restoration of "shaded riverine aquatic" habitat is partly intended to reduce water temperature in mainstem and tributary streams to improve chinook salmon spawning, incubation, and rearing conditions.

Existing efforts to monitor basic water quality in the system are substantial, but are not comprehensive enough or well enough integrated to adequately support adaptive management and ecosystem approaches to system restoration. A system-wide basic water quality program should be established. A potential path is to form a group of system water quality experts to design a comprehensive program. The group would identify significant temporal, geographic, and technical gaps in existing programs and recommend a strategy for implementing an enhanced program, including funding needs and opportunities for program integration and collaboration. The group could also be asked to recommend a process for producing integrated annual data bases and reports describing water quality conditions for the entire Bay-Delta system, including tributary streams.

SYSTEM-WIDE AQUATIC CONTAMINANTS MONITORING SUB-PROGRAM

Contaminants monitoring and related investigations are a potentially critical element of the overall monitoring and focused research program supporting Bay-Delta system restoration efforts. The development and implementation of restoration program related contaminants monitoring will be directly linked to and integrated with monitoring associated with CALFED's Water Quality Program.

The Bay-Delta system does not currently have a comprehensive program to monitor levels of contaminants (herbicides, pesticides, metals, etc.) for documenting trends in contamination levels and bioaccumulation. The Restoration Program must be supported by a comprehensive program of contaminants both to assess ________ resolution efforts and to asses how contaminants affect other types of restoration efforts. Full implementation of large-scale long-term monitoring efforts should be preceded, or accompanied by focused research to assess possible contaminant effects (e.g., growth, mortality, reproduction) on fish and aquatic macroinvertebrate populations. The long-term monitoring programs and the focused studies will be needed to reliably link variations in fish and macroinvertebrate populations and ecosystem processes with contaminant levels and to fully understand the dynamics (sources, fates, etc.) of system contaminants.

Cooperation with existing programs (such as the SF Estuary RMP, USGS' NAWQUA, USGS' SF Bay Program, Sacramento Coordinated Monitoring Program, DPR's programs, and CVRWQCB is Sacramento River Watershed Program), as appropriate, to develop and implement a comprehensive program of contaminants monitoring, toxicity monitoring, bioaccumulation monitoring, and fish condition monitoring for the Bay-Delta system are essential to this subprogram.

ESTUARY AND RIVER WETLAND AND RIPARIAN HABITAT MONITORING SUB-PROGRAM

The ERPP contains many objectives, indicators, targets, and actions addressing the restoration of the wetland and riparian habitat in the estuary and tributary streams, including adjacent upland areas, and the processes that create and sustain these habitats. Setting back river levees and opening areas adjacent to the estuary to tidal action are two types of actions intended to restore wetland and riparian habitats and related processes.

Neither the Central Valley nor the Bay-Delta presently has an overall habitat monitoring program. The existing efforts do not comprise a program that is sufficiently comprehensive enough to support and adaptive management approach to wetland and riparian habitat restoration.

Coordination among such groups as fish and wildlife agencies, public works agencies (e.g. U.S. Army Corps), conservation groups (e.g. Ducks Unlimited, The Nature Conservancy, etc.) and others, as appropriate. to design and implement a comprehensive program of habitat monitoring for the estuary and its tributaries will be encouraged.

ESTUARY PRIMARY PRODUCTIVITY AND NUTRIENT SOURCE MONITORING SUB-PROGRAM

Nutrient concentrations and primary productivity levels are fundamental variables affecting the condition of the estuary's biotic community, and must be integrated into any comprehensive analyses of fish and zooplankton responses to restoration efforts. Existing programs, such as the compliance monitoring conducted by USBR and DWR and USGS' regular Bay water and _____ surveys provide substantial information, however, enhancements are needed to support the Restoration Program. The most important enhancement of this sub-program required for restoration purposes is the extension of lower estuary (South Bay through Central Bay) sampling into shoal and other shallow water areas. USGS, DWR and USBR will continue their past efforts to coordinate and enhance their existing estuary water quality programs, which include measurement of key estuary nutrient and primary production variables.

MAINSTEM RIVER AND TRIBUTARY AQUATIC BIOLOGICAL COMMUNITY MONITORING SUB-PROGRAM

Existing aquatic biological monitoring in Central Valley streams is heavily focused on a few anadromous fish species, particularly chinook salmon, steel head, striped bass, and white sturgeon. Although some broader aquatic ecological is currently obtained from incidental catches during species-specific sampling and from special investigations and research by agencies and universities, more comprehensive monitoring of the entire aquatic biological community in Central Valley mainstream rivers and tributaries is required to support the Restoration Program. This expanded monitoring is required for two reasons. First, habitat restoration efforts (and other factors) may affect the abundance and distribution of species which prey on, are preyed upon, or compete with higher profile species. A full understanding of the response of these higher profile therefore requires information about responses of associated species. Secondly, the ERPP's restoration objectives are intended to promote general ecosystem health. Improving and monitoring the general condition of the aquatic community, particularly resident native fish species, is consistent with that approach.

A comprehensive aquatic biological community monitoring program for Central Valley streams should be developed through a cooperative process involving fisheries, water quality, and water development agencies, their stakeholders, and appropriate experts from the academic community. The monitoring will likely include routine seasonal sampling for fish and benthic macro invertebrates at representative stream sites throughout the system for fish, macro invertebrates, and algae. Predatory fish monitoring at key times at sites where they are likely to concentrate (e.g. barriers, diversion dams, fish ladders, etc.) may also be needed. The monitoring should coordinate with and support DFG and Regional Water Quality Control Board efforts to develop and standardize bioassessment procedures and interpretation.

ESTUARY ZOOPLANKTON MONITORING SUB-PROGRAM

The condition of the zooplankton community is an important indicator of how the ecosystem is responding to restoration efforts. The zooplankton community and individual zooplankton species generally respond rapidly to changes in system productivity and hydrology and can be used as an early indication of the effects of some restoration actions. The estuary's zooplankton are also an important food source for many fish species and life stages. Consequently, the abundance, distribution, and composition of zooplankton in the system are important variables to consider in interpreting the response (e.g. growth and survival) of the fish community to restoration efforts. Dramatic changes in the zooplankton community have taken place in recent years and may take place in the future. Changes of this kind, if not recognized, could confound efforts to understand fish community responses to restoration efforts.

The IEP has been monitoring zooplankton in the estuary since the early 1970s. The group is currently in the process of expanding the geographical coverage of its monthly surveys into the lower embayments provide a more geographically complete picture of the zooplankton community. Coordination with the IEP program to meet the habitat restoration monitoring needs will be pursued.

ESTUARY BENTHOS MONITORING SUB-PROGRAM

The monitoring program supporting adaptive management approach to Bay-Delta system restoration must include monitoring of the estuary's benthic invertebrate community. The benthic community has undergone dramatic change in recent history, and is vulnerable to future change, primarily related to invasion of exotic species. These changes have had dramatic effects on estuarine ecosystem processes that potentially could impact the ecosystem's responses to restoration efforts.

There are two existing estuarine benthic monitoring program that collectively may provide adequate information for this effort. One is conducted by DWR under the auspices of the Interagency Ecological Program, and the second is conducted by SFEI's Regional Monitoring Program.

ESTUARINE FISHES MONITORING SUB-PROGRAM

The Bay-Delta system's estuarine fish community is the subject, directly or indirectly, of many of the restoration plan's implementation objectives. The estuary's fish (fish, shrimp, and crab) community is extremely complex and dynamic, with the abundance and distribution of species responding dramatically to seasonal, annual, and longer term changes in estuarine conditions. It is therefore essential that restoration efforts are supported by a robust and comprehensive program of monitoring of important species, life stages and habitats of estuarine fishes.

San Francisco Bay-Delta fishery management and protection is currently supported by substantial monitoring and research efforts, much of it conducted under the auspices of the IEP (see Appendix _). Anadromous fish monitoring is currently expanding to support the information needs of CVPIA-CAMP. The information generated by existing fishery monitoring will be incorporated to support the adaptive management approach to restoration, and any necessary enhancements required by the approach will be developed cooperatively with existing programs. One required enhancement is the expansion of monitoring in perennial and seasonal shallow water and riparian habitats .

CENTRAL VALLEY SALMONID MONITORING SUB-PROGRAM

The Central Valley salmonid monitoring sub-program provides information on trends in abundance of adult and juvenile salmonids (four races of chinook salmon and steelhead) as well as changes in their freshwater and estuarine habitat.

Salmonid monitoring is broken down into the following major components:

- estimates of the ocean and inland harvest of adult chinook salmon and juvenile steelhead;.
- estimates of the numbers of adults returning to spawn in several key streams and to State and federal hatcheries;
- daily, weekly, and annual information on the numbers and lengths of juvenile salmonids leaving several key streams during their outmigration;
- daily, weekly, and annual information on the numbers and lengths of juvenile salmonids entering and leaving the Sacramento-San Joaquin Delta;
- daily estimates of the numbers and lengths of juvenile salmonids salvaged at the State and federal fish protective facilities;
- a constant fractional marking program at all Central Valley salmonid hatcheries to help determine the hatchery contribution to commercial and recreational catches, spawning escapement and straying between streams.

Sample frequency will vary by site and season. Much of the habitat work will be conducted in conjunction with other monitoring program elements. Several areas of special studies will be needed to understand the factors controlling salmonid distribution and abundance. Including race and stock identification, use of the estuary for salmon rearing and the effects of hatcheries on the fitness of various stocks.

As with most of the monitoring elements, program success depends on successful coordination of the program with existing programs such as the Interagency Ecological Program, individual programs by resource agencies and local irrigation districts, and elements of the Central Valley Project Improvement Act.

INLAND SPORT FISHERY SURVEY SUB-PROGRAM

The quantity and quality of sportfishing opportunities in the Bay-Delta system are key indicators of the system's response to restoration efforts. Monitoring the status of this beneficial use is an important element of the overall assessment of the success of restoration efforts. Also, inland harvest rates (derived from sportfishing surveys) are key population dynamics variables that must be monitored and incorporated into effective species management decisions. The basic elements of the sportfishery survey program should include:

- randomly stratified (geographical, time-of-day, and day-of-week strata) boat-based high speed surveys to estimate angler use

- contacting a representative sample of observed (above) anglers to obtain effort and catch (species, size, etc.) information

- collection and processing of tags from sport caught fish

A Bay-Delta sport fishery survey program is currently under development to support the information needs of the CCPIA's anadromous species "doubling Plan". In cooperation with CVPIA-CAMP, IFP, and DFG's Inland Fisheries Division, this survey will be designed and implemented to cover all sport-caught species to support the broader ecological goals of the Restoration Program.

"Real-Time" Monitoring Sub-program

"Real-time" monitoring of fish in the lower rivers and upper estuary to support CALFED Operations Group decision-making will play an important, ongoing role in system restoration. "Real time" fish monitoring involves intensive fish sampling (and quick turn-around of data) at key locations to provide water project operators and their stakeholders with information about fish species abundance and distribution so opportunities to improve conditions for fish can be taken and potentially harmful project operating conditions avoided. A program focused on the critical spring-early summer period has been in place since 1995.

"Real time" monitoring also occurs in the lower San Joaquin River where dissolved oxygen monitoring is conducted by DWR to trigger head-of-Old River barrier operations in the fall. DWR will continue this monitoring activity.

As the Restoration Program and other CALFED core programs develop needs for additional real time monitors will be identified and existing programs adjusted through cooperation with the IEP and the operations group.

Monitoring Data Management and Dissemination Sub-program

Although data management is an integral part of each of the subprogram, there will be an overall data management system for the purposes of the habitat restoration plan. The adaptive management approach to ecosystem restoration requires that all supporting monitoring data be readily available for integrated analysis and reporting.

The IEP's information technology staff is in the process of developing a relational data base management system for storage and retrieval of monitoring data from all the sub programs. The same system will be used for all IEP and CVPIA-CAMP monitoring data. Data (including metadata) from the various general ecosystem monitoring sub-programs and action-specific evaluations will be transferred from data collectors to IEP information technology staff. These data will be error-checked and loaded into the IEP relational database. A database administrator will monitor data transfers and IEP QA/QC guidelines for data loading and management will be followed. The RDBMS relates diverse types of information collected by the monitoring programs and will enable users to retrieve information using a simplified querie system. Additionally, reports and model output will be presented on the server.

Action-specific Monitoring and Evaluation

The program of "General Ecosystem Monitoring" described in the preceding pages and in Appendix __ is primarily intended to monitor large-scale ecosystem responses to the collective efforts of the Restoration Program. Although, this general ecosystem monitoring will contribute to the evaluation of individual restoration actions, the adaptive management approach to ecosystem restoration also requires action-specific monitoring. Rigorous monitoring and assessment plans, and associated performance criteria, will be developed for each restoration action as part of the project plan. The following lists are partial of some of the types of monitoring that may be used to evaluate various categories of restoration actions.

River and Delta-Channel Flow Modification

- intensive juvenile fish distribution (transport) sampling
- experimental mark and recapture releases of juvenile salmon
- dye release studies to document channel hydraulics (e.g., flow splits)

River Temperature Control

- localized, intensive temperature monitoring for temperature model verification
- localized, intensive fish species habitat use surveys

Aquatic Contaminants Input Reduction

- before/after toxicity testing
- before/after localized benthic macroinvertebrate and fish community sampling
- chemical fate studies

Hatchery Propagation and Release

- release site-specific carrying capacity and predation/competition assessments
- marking of released fish to assess contribution to populations and fisheries
- assessment of hatchery propagation effects on population genetics

Fish Passage and Screening Facilities

- laboratory and field screen impingement investigations
- screen cleaning and clogging monitoring
- before/after diversion entrainment rate studies and associated local ambient fish abundance and distribution surveys.
- before/after fish surveys to document habitat use above barriers
- before/after predator monitoring at new facilities

Tidal Wetlands and Shallow-water Habitat Restoration

- site specific before/after areal surveys of restoration areas, connecting and buffer zones
- vegetation transects to measure plant stem density, species composition, above/below ground biomass, succession rate, etc.)
- localized fish surveys at restoration and reference sites to document habitat use
- wetland bird surveys, including nesting surveys
- live trapping to document changes in small mammal and predatory mammal abundance.
- sediment deposition and scour monitoring

Juvenile Salmonid Predator Habitat Removal

- Pre and post project predator surveys in off-channel ponds
- site-specific predator abundance and food habits surveys

Salmon Spawning and Rearing Habitat Improvement

- Pre and post project aquatic macro-invertebrate and fish community surveys
- Pre and post project geomorphic surveys including measures of gravel embeddedness, intergravel oxygen levels and temperatures, water surface elevation and gradient
- Post project gravel movement and retention
- Flow monitoring
- Pre and post project spawning use surveys at project and reference sites
- Pre and post project measurement of S_____ ______ Aquatic habitat

Legal and Illegal Fish Harvest Management

- before/after compliance rate assessments (citations/contact)

<u>Riverine and Riparian Habitat Improvement</u>

- before/after channel flow and velocity distributions to assess sediment scour and deposition patterns
- levee- top to levee-top stream bed and riparian corridor topographic surveys
- stream bed substrate, depth, and velocity transects
- riparian vegetation transects to measure shaded-riverine cover, snag density, riparian corridor width, plant composition, over story and understory composition and density, leaf litter density, succession rates, basking sites, etc.
- bird and mammal surveys (hooting, VCP's, misting netting for bats, nesting sites, etc.)

Boat-Wake Erosion Control

- Boat access and speed limit compliance monitoring
- Bank erosion mapping at representative treatment and control sites

Monitoring Implementation Strategy

The conceptual ecosystem monitoring program proposal described in the previous pages is ambitious and expensive. When fully implemented, it will provide baseline monitoring data needed to determine trends in important ecosystem components and, in some cases, lead to hypotheses about causes of the observed trends which can be tested in special studies or action-specific evaluations. It should be noted that, at the population level, it will be difficult to quantify the effects of a specific restoration measure. For example, the variation in numbers of chinook salmon returning to spawn is a function of natural variability in instream, estuarine, and oceanic conditions as well as such restoration actions as gravel replenishment, predator isolation, more estuarine shallow water habitat and changes in fishing regulations.

The only economically feasible way to implement a comprehensive ecosystem monitoring program is to fully integrate and coordinate the program with existing and proposed monitoring activities of several State and federal agencies and local entities. These monitoring activities include programs by the:

- Interagency Ecological Program
- San Francisco Estuary Institute
- Department of Fish and Game
- Department of Water Resources

- U.S. Fish and Wildlife Service (including the CVPIA-CAMP)

- U.S. Geological Survey

- local water district monitoring

- Pacific Gas and Electric

- Regional Water Quality Control Boards

- Universities

Although the individual monitoring activities often have different objectives, they all provide essential baseline monitoring data and special studies needed to assess, understand, and manage the complex Central Valley system.

The key steps to implement the monitoring program are:

1. Obtain consensus on the conceptual program with flexibility to meet individual agency or program needs.

2. Develop detailed program plans and budgets for individual elements (stations, parameters, sampling frequency) and data handling, storage, and dissemination.

3. Identify monitoring elements in the approved program that are being conducted as part of existing or proposed monitoring activities, or can be modified to meet the both habitat restoration plan and existing program objectives.

4. Cooperation between agency and stakeholders to help ensure that the existing efforts are continued, and where possible, expanded.

5. Use new funding to fill in the gaps.

Successful implementation of the ecosystem monitoring program will require that an agency, or entity, take the lead in moving from concept to a detailed program. It will also coordinate and integrate existing monitoring efforts within the overall program. Agencies, with stakeholder input, will determine an implementation process or institution which will to respond to the increased geographic and technical scope of the comprehensive monitoring. Appropriate technical staff and consultants from the agencies and stakeholders will be assembled by the implementation institution/process to develop the detail required for implementation of the monitoring program. Conceptual program elements may be modified and based on priority and available funding.

The value of the general ecosystem and action-specific monitoring will largely be determined by how effectively the data is used. The many data sets generated by the monitoring must be compiled, analyzed, and reported in a comprehensive, integrated fashion. The analysis and interpretation must specifically address restoration objectives, indicators, and targets. In addition, the analysis and reporting of monitoring data must be directly linked to the decision making processes associated with an adaptive management approach to restoration. To maximize the value of the monitoring program, a high-level technical team of agency, stakeholder, and academic ecosystem experts should be established and be charged with:

- working cooperatively with individual entities and investigators conducting general ecosystem and action-specific monitoring elements to ensure that data is available in a form and time frame useful to program analysis,

- conducting data analysis and preparing reports (or coordinating analysis and reporting) specifically addressing restoration objectives, indicators, and targets, and

- formulating recommendations for management regarding ongoing and proposed restoration efforts.

Another important function of the group will be to continuously evaluate the monitoring program, and recommend changes to management as needed.

The high-level technical team will be an ongoing part of the ecosystem restoration process and will take the steps necessary (funding, agreements with agency managers, etc.) to ensure that team members have sufficient time and resources to perform their critical role.

APPENDIX

These descriptions (below) provide additional detail about some of the general ecosystem monitoring sub-programs, including a brief description of individual sub-program "elements". Some proposed elements require significant development effort before a meaningful detailed description can be provided, detailed sub-program descriptions have not been provided in this appendix.

RESTORATION MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: River and Estuarine Flow Monitoring

SUB-PROGRAM PURPOSE: To monitor effects of proposed restoration projects on water flow distribution, flow and transport rates, water elevation, and residence times throughout the Central Valley watershed with primary focus on the Sacramento-San Joaquin River system and delta and Suisun Bay and marsh.

SUB-PROGRAM ELEMENT DESCRIPTIONS: The ERPP includes many flow-related ecological zone targets designed to support processes such as sediment and nutrient transport, fish and invertebrate passage and transport, entrapment zone location and attraction flows. It is also the case that numerous restoration projects are being proposed throughout the Central Valley watershed that include such tasks as constructing setback levees along some of the rivers flowing into the delta to create shallow water riparian habitat, raising the floor elevation of delta islands and returning them to tidal marsh, deepening of channels to decrease water temperature, and developing habitat in flood ways, which can significantly modify the existing flow distribution, rates, and residence times within the river, delta, and bay system. These proposed modifications to the ecosystem can affect the position of X2 salt water intrusion into Suisun Bay and Marsh as well as the delta, vary flood flow water surface elevations, and sediment deposition and scouring of river levees and channel bottoms.

Numerous flow and water elevation monitoring sites throughout the riverine region of the Central Valley are now operated by various agencies which can be used to document achievement of desired flows and monitor responses to restoration program actions. Most of these sites have been providing flow and water elevation information for a long time and will most likely continue to do so well into the future. These historical records will be invaluable during the evaluation phase of the restoration projects.

Unfortunately, flow data are not as plentiful within the tidal-affected delta and bay region of the system as compared to the riverine region. There are long time-series of water elevation data available for the delta and bay, but the data from within the delta are often in question because of subsidence effects. Only during the last several years have time-series of flow and velocity data been collected within the delta and bay by the USGS, under the auspices of the IEP, using acoustic technology. The instruments being used are ultrasonic velocity meters (UVM) and acoustic Doppler current profilers (ADCP). UVMs are fixed installations that are capable of producing 15-minute interval time-series of flow, mean cross-sectional velocity, and water-surface elevation data. ADCPs are used as portable flow measuring devices for use in calibrating UVM sites, and for deployment on a channel bottom to continuously monitor the velocity distribution of the water column above the instrument. Presently there are 10 UVM flow monitoring sites within the delta, however, they are located at important locations or flow splits. Daily delta outflow will soon be estimated by UVMs. ADCPs have been used during the last few years to collect time-series of velocity profiles at several locations in Suisun Bay.

It appears that there is an adequate number of flow and water elevation monitoring sites in the riverine part of the system to sufficiently monitor flow conditions for the purpose of assessing restoration effects, however, there will probably be serious flow data deficiencies within the delta and bay depending upon the location of the restoration project. Restoration management will cooperate with the USGS in developing new methods to collect continuous flow data within the delta (refer to "Key Focused Research") without using UVMs. If this successful, these USGS efforts will provide additional flow time-series data at sites other than the present UVM sites.

KEY FOCUSED RESEARCH TOPIC AREAS:

1) Investigate the utility of obtaining flow data in the delta by deploying an ADCP on the channel bottom at the selected monitoring locations and attempt to relate the velocity profile data provided by the ADCP to tidal flow using a relation developed from flow measurements made with the portable ADCP flow measuring system. The time and cost of installing a UVM flow monitoring site is quite high. In order to install a UVM site, construction permits must be obtained from numerous agencies and transducer mounting piles must be purchased and driven into the channel bottom. The purchase and driving of piles is costly and requires substantial regulatory documentation.

RESTORATION MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: System-Wide Basic Water Quality Monitoring

SUB-PROGRAM PURPOSE: To routinely monitor the basic water quality variables (listed below) that define the fundamental condition of aquatic habitat in the Bay-Delta system.

SUB-PROGRAM ELEMENT DESCRIPTIONS (parameters):

These water quality variables are essential for interpreting biological sampling data, and are therefore an important component of the comprehensive monitoring effort. They are:

- Water Temperature - Regulates chemical and biological processes and defines habitat suitability for many species, particularly in mainstem rivers and tributaries.
- Salinity - Affects the distribution of many plant and animal species and life stages in the system. Also, an indicator of important physical processes, such as estuarine water circulation and mixing. Defines the relative proportion of freshwater and seawater at different locations in the estuary and salt loads from upstream sources. In low salinity portions of the system, specific conduction is a more appropriate measure.
- Turbidity (Light Penetration) - Affects primary production in the estuary and defines the position of the biologically important entrapment zone. Change in turbidity is a possible juvenile salmon migration cue and controller of predation in system rivers.
- Dissolved Oxygen - Indicator of net metabolism in the system. Both low and supersaturation levels can limit species abundance, distribution, and migrations in the mainstem rivers and tributaries.
- Chlorophyll concentration - An index of phytoplankton abundance, the microscopic algae that are the traditional box of the food web in the estuary.
- pH - A quantitative expression for acidity or

alkalinity of the area sampled.

- Organic Carbon - Provides information on sources and fluxes of the primary support of the estuarine food chain. Inputs from the rivers to the Delta and within the Delta and bays would be measured for this variable.

SUB-PROGRAM ELEMENT DESCRIPTIONS (COMPONENT BY AREA):

1) **Mainstem River and Tributary Basic Water Quality Monitoring**: The comprehensive monitoring program will include a routine, systematic program of basic water quality monitoring in mainstem rivers, tributaries, and terminal reservoirs. Although existing basic water quality sampling efforts are conducted for specific programs, they are collectively insufficient for supporting the adaptive management approach to ecosystem restoration. Reasons for this include:

- A cohesive and comprehensive program incorporating strategically located monitoring sites and providing adequate geographical and temporal coverage does not exist throughout the mainstem river and tributary streams.

- On the San Joaquin River system, programs have not been developed to provide data to make coordinated operational decisions regarding the attainment of water quality objectives.

- A quality controlled system of data handling, storage, retrieval and analysis for a comprehensive water quality program does not exist.

- Some localized existing basic water quality sampling efforts are reasonably comprehensive, but are short-term efforts associated with special projects (e.g. FERC relicensing or model development).

A cooperative effort with entities conducting existing basic water quality sampling programs (USBR, DWR, USGS, fish and wildlife agencies, communities, etc.) will be needed to design a basic water quality program to support its adaptive management approach to restoration. To the maximum extent possible the design will build upon existing sampling, and integrate existing and new sampling efforts. The anticipated basic components of this program are:

- Temperature, D.O., and light penetration profiles in terminal Reservoirs in the vicinity of reservoir outlets. Basic water quality conditions in terminal reservoirs directly influence downstream conditions and in some cases can be manipulated (e.g. controlling the depth of river releases) to improve conditions downstream.

- Continuous temperature monitoring in mainstem rivers and tributaries, with stations located at points where significant temperature influences are likely (at dams, mouths of major tributaries, etc.)

- Sampling of other basic parameters (e.g. turbidity, specific-conductance, organic carbon) at all stream temperature stations (above) and additional ecologically relevant locations.

- Real-time salinity and flow data at key points along the San Joaquin River system to allow coordinated management of salt loads and flows to meet water quality standards.

- A system of data storage and retrieval for all sites will be developed. Emphasis will be placed on analysis of the data to provide ecologically relevant information to support an adaptive management approach.

2) **Estuarine Basic Water Quality Monitoring**:

The DWR and USBR and DFG, working under the auspices of the Interagency Ecological Program, conduct a water quality monitoring program covering San Pablo Bay and through the Delta. This program was recently reviewed and revised in

1995 and will continue to evolve as information needs change. The revised program has been accepted by the State Water Resources Control Board in their Water Quality Control Plan 95-6. The three major elements of this revised program are:

- A network of continuous recording, multi-parameter water quality sites at key locations including Sacramento River and San Joaquin River inflow points to the Delta, CVP and SWP export facilities, and various channel locations throughout Suisun Bay and the Delta.
- A monthly boat sampling program that runs up the estuary collecting near-surface water quality data and lower trophic data with stops at discrete sites to measure conductivity, temperature profiles and collect phytoplankton and zooplankton samples.
- Special studies that focus on specific problems.

The USGS also makes monthly water quality measurements along the central deep channel from the southern limit of South San Francisco Bay to Rio Vista on the Sacramento River. This sampling design, conducted since about 1968 provides descriptions of water quality along the longitudinal axis of the San Francisco Bay-Delta system.

These existing water quality monitoring program generally adequate today's information needs and contains enough sites to monitor trends, but is limited by funding. However, to meet the objective of determining ecological changes resulting from restoration activities, additional sites (and possibly additional parameters) should be added to supplement the existing program. For example, more sites should be added in the shallows of Grizzly and Honker Bays and downstream in San Pablo, Central and South bays, dead-end sloughs in the northern and eastern Delta, and the southern Delta. In addition, a comprehensive program for data analysis and evaluation should be developed and water quality and fish sampling programs need to be better coordinated so that it is easier to perform integrated analysis of the two types of data.

3) **Integrated Analysis of Basic Water Quality Conditions:** Basic water quality sampling in the system is, and will probably continue to be, obtained and reported from a variety of individual programs, each with their own objectives and information needs. The comprehensive, integrated assessment of this information will be promoted by establishing and supporting a team of experts whose objective is to produce and distribute integrated analysis and reports (maps, contour plots, and time series plots) of the variables listed above on an annual basis and to make sure there is an analysis plan for the data. An integrated-analysis approach will also be served by a single entity which maintains all relevant basic water quality data in a computer file server and including the data, as appropriate, in geographic information system.

KEY FOCUSED RESEARCH AREAS:

1) Analytical and field reconnaissance efforts to design a comprehensive basic water quality monitoring program for the system, built-on and integrated with existing monitoring efforts.
2) Development of a plan for storage, retrieval and analysis of water quality data.
3) Development of a computer model or models to predict water quality conditions in unmonitored areas and evaluate restoration scenarios.

RESTORATION MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: System-Wide Aquatic

Contaminants Monitoring

SUB-PROGRAM PURPOSE: To monitor levels of contaminants potentially harmful to aquatic life, system-wide, in water, sediments, and biota for documenting trends in contamination levels, bioaccumulation, and identifying potential biological effects; and to identify time periods and locations where specific contamination reduction efforts should be focused.

SUB-PROGRAM ELEMENT DESCRIPTIONS:

1) **Bay-Delta System Water and Sediment Contaminants Monitoring:** The Bay-Delta system does not currently have a comprehensive, routine aquatic contaminants (herbicides, pesticides, metals, etc.) monitoring program to help identify areas or time periods where contaminants are an ecological concern and provide trend information on contaminant levels. A core program modeled after, and building upon, the Comprehensive Conservation and Management Plan's (SF Estuary) Regional Monitoring Program, should be established for the entire system (terminal reservoirs to the Golden Gate) to provide this information. Emphasis should be given to monitoring those contaminants most likely to cause an adverse biological effect. Collaboration with existing monitoring programs (e.g., SF Estuary RMP, USGS' NAWQUA, USGS' SF Bay Program, Sacramento Coordinated Monitoring Program, DPR's programs, and CVRWQCB Bay Protection and Toxic Clean-up Program) could be considered as an implementation strategy.

2) **Toxicity Monitoring:** Water and sediment toxicity testing should be integrated into the chemical and biological monitoring programs. Toxicity surveys can provide a direct link from contaminant levels and adverse biological effects, and help insure that aquatic organisms are protected from toxic materials. If toxicity is observed, Toxicity Identification Evaluations (TIEs) and other techniques can help determine what chemicals are the cause, so contaminant reduction efforts can directed effectively. Long-term toxicity monitoring can provide a direct measure of potential biological benefits of contaminant reduction programs.

   Toxicity monitoring has the potential to be logistically difficult and expensive. For this reason, responsible agencies with current programs in place and experts should cooperate to design and help implement a toxicity monitoring program that is both practical and useful.

3) **Bioaccumulation Monitoring**: The SFEI is establishing a program to investigate and monitor contaminants (PCB's, dioxin, pesticides, mercury, etc.) in fish and shellfish tissue from San Francisco Bay through Suisun Bay, primarily to protect human health and track tissue contaminant levels through time. The scope of this new program should be expanded into the upper estuary, Delta, and rivers and adapted to address potential adverse effects to fish and aquatic invertebrate populations and be coordinated with the State's Mussel watch program.

4) **Fish Condition Monitoring:** If fully implemented, the overall monitoring program (including existing programs) will include routine collection of juvenile and adult fishes from throughout the Bay-Delta system. A systematic examination of fish collected during these efforts can provide a rapid measure of fish health that can be monitored to identify contaminant problem areas and monitor trends in fish health.

   Full implementation of these long-term monitoring elements should be preceded, or accompanied by focused studies as listed below. These studies should be closely coordinated to maximize their use to assess possible effects (e.g., growth, mortality, reproduction) on fish populations. The long-term monitoring programs and the focused studies will be needed to reliably link variations in fish populations and ecosystem processes with contaminant levels, or to fully understand the dynamics (sources, fates, etc.) of system contaminants.

KEY FOCUSED-RESEARCH TOPIC AREAS:

1) Investigations of contaminant effects on fish and invertebrate populations and ecosystem processes such as recommended by IEP's Contaminant Effects Team and other established technical groups. Emphasis should be on the integration of contaminant effect investigations with the aquatic biological monitoring program.

2) Pilot-level water and sediment contaminants studies and comprehensive literature reviews are required to determine appropriate sampling locations, frequency, and contaminant constituents for long-term monitoring. An adaptive sampling design should be considered to address spatial and temporal distribution of different contaminants and fish populations, varying habitat types, and the hydrodynamics characteristics of the sampling sites.

3) Development and implementation of biomarkers (e.g., hormonal disruption, histopathology, DNA damage) for assessing sublethal contaminant effects on fish.

4) Development of a multi variate fish condition index that is biologically meaningful and easily obtained during routine fish sampling. Possible variables include lesions, tumors, condition factor, and simple blood tests. A larval fish condition index would be especially useful in assessing population level effects.

RESTORATION MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Estuary River Wetland and Riparian Habitat Monitoring Sub-program

SUB-PROGRAM PURPOSE: To monitor the ecological components of mainstem and tributary areas to evaluate the condition of wetland and riparian habitat.

SUB-PROGRAM ELEMENT DESCRIPTIONS:

Currently, there is no overall program in the Central Valley that monitors ongoing changes to habitat types or availability. The existing efforts do not collectively comprise a program that is sufficiently comprehensive to support an adaptive management approach to wetland and riparian habitat restoration.

In order to develop a program to monitor the system's wetland and riparian habitat conditions three important, related questions should be answered:

1) Are individual habitat restoration actions successful?

   The results of individual efforts to restore habitats, such as tidal marsh lands and shaded riverine aquatic habitat, are difficult to predict. Although individual habitat restoration projects will be carefully planned and engineered, it will still be necessary to carefully monitor short and long term results to identify and guide any necessary follow-up activity to assure that the habitat values envisioned for a project are achieved.

2) Is there net improvement in the system's habitat conditions?

   Habitat improvement-related implementation objectives can either be enhanced or offset by system changes that are unrelated to specific restoration efforts. In order to know that net overall improvement in desired habitat objectives is being achieved, habitat conditions throughout system must be regularly monitored and evaluated.

3) What are the values of restored habitat and how are those values changing over time?

Habitat improvement efforts must be evaluated in two general ways. The most basic way is to simply consider the areal extent of restoration (e.g. the number of acres of riparian forest). As important, is the quality of the habitat and ecosystem value it is providing. Connectivity, vegetation productivity and density, rate of succession, and wildlife use are just a few examples of habitat values that will need to be considered when evaluating the success of its restoration efforts and overall system habitat conditions in the future.

The program will likely include the following general components:

- Regular (every 3 to 5 years) large-scale aerial or satellite photo surveys along all major system rivers and the estuary to measure the system-wide extent (and to some extent, other attributes) of targeted habitat types and river bed morphology.

- Regular (seasonal and annual) and flood-event driven more fine scale aerial photo surveys of restoration project sites and representative reference sites.

- Regular (every 3 to 5 year) system-wide boat and ground-based estuarine bathymetric surveys to support hydrodynamics monitoring efforts and provide information on estuarine depth-distribution characteristics.

- Regular ground surveys of vegetation characteristics and wildlife (including special status and exotic species) in habitat restoration project areas, and in randomly (stratified) selected sites throughout the system.

- Inclusion of all wetland riparian habitat and habitat use monitoring data in a comprehensive Geographic Information System.

The fish and wildlife agencies, public works agencies (e.g. U.S. Army Corps of Engineers), conservation groups (e.g. Ducks Unlimited, nature conservancy, etc.), and others as appropriate will work to design and implement a comprehensive program of habitat monitoring for the estuary and its tributaries.

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Estuary Primary Productivity and Nutrient Monitoring

SUB-PROGRAM PURPOSE: To monitor key nutrient and primary production variables in the Bay-Delta estuary.

SUB-PROGRAM ELEMENT DESCRIPTIONS: Nutrient concentrations and other factors affecting system productivity levels are fundamental variables affecting the condition of the estuary's biotic community, and must be integrated into the analyses of fish and zooplankton responses to restoration efforts. The key nutrient and primary production-related variables are:

- chlorophyl concentration

- chlorophyl species composition

- light penetration

- solar insolation

- dissolved nitrogen

- particulate, dissolved, and total organic carbon

- water temperature

To a large extent this productivity and nutrient information is now gathered by existing programs (listed below). These existing programs should cooperate to enhance them as necessary to meet the various program objectives and incorporate their information into the overall ecosystem monitoring program.

1) **USGS Water Quality Surveys:** USGS

(Menlo Park) conducts routine monthly water quality sampling, including the variables listed above, (see "System-wide Basic Water Quality Monitoring" sub-program description) at __ channel sites from South Bay to Rio Vista. Through interprogram cooperation, the surveys will be expanded to include appropriate shoal stations.

2) **DWR/USBR/DFG Water Quality Compliance Monitoring**: The Department of Water Resources and U.S. Bureau of Reclamation, working under the auspices of the Interagency Ecological Program, conduct a water quality monitoring program through Suisun Bay and the Delta, including most of the variables listed above. This program was recently reviewed and revised in 1995 and is described in the "System-wide Basic Water Quality Monitoring" subprogram description.

   Information from these surveys will be incorporated into the overall monitoring program.

KEY FOCUSED RESEARCH AREAS:

1) Pilot monitoring/studies of primary production in estuary shoal areas.
2) The role of micro zooplankton in estuary productivity.
3) Estimation of, and factors affecting, total system productivity (up through the zooplankton trophic level).
4) Differences in energy/nutrient sources between geographical areas of the estuary.
5) Occurrence and role of introduced phytoplankton species in the Estuary.

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Mainstem River and Tributary Aquatic Biological Community Sub-Program

SUB-PROGRAM PURPOSE: To monitor the ecological components of mainstem and tributary areas to evaluate the condition of wetland and riparian habitat.

SUB-PROGRAM ELEMENT DESCRIPTIONS: The assessment and adaptive management of restoration efforts must be supported by more consistent and broad monitoring of the entire community for two reasons. First, habitat restoration efforts may affect the abundance and distribution of species which prey upon, are eaten by, or compete with higher profile species such as chinook salmon. A full understanding of the response or lack of response of these higher profile species, therefore requires information about changes in the abundance and distribution of associated species. Secondly, restoration objectives are intended to promote general ecosystem health. Improving and monitoring the general condition the aquatic community, including resident native species, is consistent with that approach.

Existing aquatic biological monitoring in Central Valley mainstem rivers and tributaries is heavily focused on a few anadromous fish species, particularly chinook salmon, steelhead, striped bass, and white sturgeon. Limited amounts of broader aquatic ecological information is available from incidental catches during species-specific sampling and from special investigations by agencies and universities.

To meet the Restoration Plans, an adequate program would consists of routine aquatic biological community monitoring in Central Valley mainstem rivers and tributaries below terminal reservoirs. This monitoring will likely include routine seasonal sampling for fish and benthic macro invertebrates at representative stream sites throughout the system. Predatory fish monitoring at key times at sites where these predators are likely to concentrate (i.e. barriers, diversion dams, fish ladders etc.) may also be needed.

KEY FOCUSED RESEARCH AREAS

1 Studies evaluating predator/prey relationships along key migration routes.

2 Food availability studies along alternative migration routes

3 Determine factors affecting path of migration utilized by outmigrants.

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Estuary Primary Productivity and Nutrient Monitoring

SUB-PROGRAM PURPOSE: To monitor key nutrient and primary production variables in the Bay-Delta estuary.

SUB-PROGRAM ELEMENT DESCRIPTIONS: Nutrient concentrations and other factors affecting system productivity levels are fundamental variables affecting the condition of the estuary's biotic community, and must be integrated into the analyses of fish and zooplankton responses to restoration efforts. The key nutrient and primary production-related variables are:

- chlorophyl concentration
- chlorophyl species composition
- light penetration
- solar insolation
- dissolved nitrogen
- particulate, dissolved, and total organic carbon
- water temperature

To a large extent this productivity and nutrient information is now gathered by existing programs (listed below). These existing programs should cooperate to enhance them as necessary to meet the various program objectives and incorporate their information into the overall ecosystem monitoring program.

1) **USGS Water Quality Surveys:** USGS (Menlo Park) conducts routine monthly water quality sampling, including the variables listed above, (see "System-wide Basic Water Quality Monitoring" sub-program description) at __ channel sites from South Bay to Rio Vista. Through interprogram cooperation, the surveys will be expanded to include appropriate shoal stations.

2) **DWR/USBR/DFG Water Quality Compliance Monitoring:** The Department of Water Resources and U.S. Bureau of Reclamation, working under the auspices of the Interagency Ecological Program, conduct a water quality monitoring program through Suisun Bay and the Delta, including most of the variables listed above. This program was recently reviewed and revised in 1995 and is described in the "System-wide Basic Water Quality Monitoring" subprogram description.

   Information from these surveys will be incorporated into the overall monitoring program.

KEY FOCUSED RESEARCH AREAS:

1) Pilot monitoring/studies of primary production in estuary shoal areas.

2) The role of micro zooplankton in estuary productivity.

3) Estimation of, and factors affecting, total system productivity (up through the zooplankton trophic level).

4) Differences in energy/nutrient sources between geographical areas of the estuary.

5) occurrence and role of introduced phytoplankton species in the Estuary.

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

ESTUARY ZOOPLANKTON MONITORING SUB-PROGRAM

SUB-PROGRAM: Estuary Zooplankton Monitoring

SUB-PROGRAM PURPOSE: To monitor key zooplankton abundance, distribution, and composition in the Bay-Delta estuary.

SUB-PROGRAM ELEMENT DESCRIPTIONS: The estuary's zooplankton community is important for evaluating restoration efforts for at least two important reasons. First, zooplankton are an important food source for many fish species and life stages, so the abundance, distribution, and composition of zooplankton in the system are important variables to consider in interpreting the response (e.g. growth and survival) of the fish community to restoration efforts. Dramatic changes in the zooplankton community have taken place in recent years and may take place in the future. Changes of this kind, if not recognized, could confound efforts to understand fish community responses to restoration efforts. Second, the condition of the zooplankton community is an important indicator of how the ecosystem is responding to restoration efforts. The zooplankton community and individual zooplankton species generally respond more rapidly to changes in system productivity and hydrology and can be used as an early indication of the effects of some restoration actions. The IEP is in the process of expanding the geographical coverage of its monthly zooplankton surveys which will provide a more complete picture of the condition of the estuary's zooplankton community. A brief description of the expanded surveys is described in appendix __ as an element of the "Estuarine Fishes Monitoring" sub-program.

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Estuary Benthos Monitoring

SUB-PROGRAM PURPOSE: To monitor the abundance, distribution, and composition of the benthic invertebrate community in the Bay-Delta estuary.

SUB-PROGRAM ELEMENT DESCRIPTIONS: The monitoring program supporting the adaptive management approach to Bay-Delta system restoration must include monitoring of the estuary's benthic invertebrate community. The benthic community has undergone dramatic change in recent history, and is vulnerable to future change, related to invasion of exotic species. These changes have had dramatic effects on the ecosystem processes that potentially could impact the ecosystem's responses to restoration efforts. Two existing estuarine benthic monitoring program; one conducted by DWR under the auspices of the Interagency Ecological Program, and the second conducted by SFEI's Regional Monitoring Program provide adequate information. The following are brief descriptions of each existing program:

1) **DWR Benthic Monitoring Program:** Benthic monitoring data are collected monthly by DWR as part of the Water Quality Monitoring Program mandated by SWRCB decision 1485. The database serves to record trends in macro-benthic organism population ranges, and keep track of exotic species introductions. The ten DWR sampling sites range from San Pablo Bay, east through the Estuary to the mouths of the Sacramento, Mokelumne, and San Joaquin rivers. The DWR Benthic program data begin in 1975. Benthic data records organisms per square meter, and benthic substrate composition. Organisms are identified mnemonically from phylum to species, and by life stage (larval, pupal, or adult). Besides being used for DWR's monitoring and reporting purposes, DWR benthic data are contributed to the San Francisco Estuary Regional Monitoring Program (RMP) for Trace Substances, Benthic Macro faunal Assemblages Study component.

2) **SFEP-RMP Benthic Monitoring:** This

component of the RMP study is a coordinated effort by SFEI, DWR, and the City and County of San Francisco. The RMP pilot study began as an effort to record baseline measurements of the condition of resident biota of the Estuary. The first summary report was a significant component of the 1994 RMP report. Data from twenty nine benthic sampling sites are collected for the RMP analysis. Eight RMP sites in Central and Southern San Francisco Bay are sampled twice yearly in February and August. Six DWR sites, located in the Western Delta, Sacramento River, Suisun Bay, and San Pablo Bay are sampled monthly. Nine stations near three sewage outfalls are sampled yearly in August as part of the City of San Francisco's LEM project. Three reference stations in Northern San Pablo and Central San Francisco Bay, are sampled in early September by the San Francisco Bay Regional Water Quality Control Board. A standardized species list is made between the four sampling projects so that the benthic organism data can be pooled for analysis.

KEY FOCUSED RESEARCH TOPIC AREAS:

1) Determine the significance of introduced bivalves on primary productivity in the estuary.

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Estuarine Fishes Monitoring

SUB-PROGRAM PURPOSE: To monitor seasonal and annual abundance and distribution of key lifestages of fish, shrimp, and crab species in the various aquatic habitats of the Bay-Delta for the purpose of documenting and understanding responses to restoration efforts and other factors.

SUB-PROGRAM ELEMENT DESCRIPTIONS: San Francisco Bay-Delta fishery management and protection is currently supported by substantial monitoring and research efforts, much of it conducted under the auspices of the IEP. Information provided by existing fishery monitoring will be incorporated to support the adaptive management approach to restoration and program adjustments will be facilitated in a cooperative effort. General enhancements that will likely be required include:

- more sampling in shallow water and riparian habitats
- expansion of monitoring process into the _____ portions of Napa River, Sonoma Creek, and Petaluma River

The following is an annotated list of the existing, enhanced, and proposed new fishery monitoring efforts that will be used to determine species and community trends:

1) **Fish Egg and Larva Monitoring:** In the past, IEP and others have conducted extensive, routine monitoring of fish eggs and larvae (E&L) in the estuary and lower rivers. Because this work is logistically difficult, labor intensive, and expensive, the IEP has suspended large-scale E&L monitoring while it undertakes a compilation, analysis, and reporting of previously collected IEP fish egg and larva data to investigate various aspects of Bay-Delta E&L dynamics and assess the need for changes in future monitoring and special studies. This information will be review when it becomes available and further field sampling will be recommended, if appropriate.

2) **Post-Larval Fish Monitoring:** The monitoring program will incorporate information from IEP's 20mm Survey, which employs sampling with a fine-mesh towed net to estimate distribution and abundance of post-larval delta smelt. Sampling is conducted every 2 weeks from April to July at 35 - 40 stations from San Pablo Bay through the Delta.

3) **IEP Summer Townet Survey:** The monitoring program will incorporate information from the IEP's Summer Townet

Survey. This annual June through August sampling has been conducted almost every year since 1959, providing the longest continuous record of juvenile fish abundance and distribution in the estuary. Sampling is conducted biweekly with a towed, small mesh net at about 31 mid-channel sites from San Pablo Bay through the Delta to monitor the annual abundance and distribution of juvenile fish in the upper estuary. The striped bass 38mm index is based on this survey.

4) **Bay-Delta Trawl Surveys:** The IEP conducts three trawling programs that provide important information about the relative abundance and distribution of juvenile and adult fishes inhabiting the open waters of the Bay-Delta.

   Collectively, these three trawl programs provide an important record of the status and trends of many Bay-Delta fish populations. These surveys will be incorporated into the monitoring plan. The longest-running of the three is IEP's Fall-Spring Midwater Trawl Survey, which samples monthly from September through March at approximately 90 sites from San Pablo Bay through the Delta. The fall portion of this survey has been conducted annually from September through December since 1967, and was expanded to sample from January through April in 1992 to better characterize the spawning distribution of delta smelt. Since 1980, the IEP has conducted monthly midwater and otter (bottom) trawl surveys at 52 channel and shoal stations from South San Francisco Bay to the lower Sacramento and San Joaquin rivers to track abundance and distribution trends of marine and estuarine fishes. These surveys also track abundance and distribution of marine and estuarine shrimp and crab species. In 1995, IEP began a Bay-Delta Kodiak trawl survey of the pre-spawning distribution of delta smelt conducted at approximately 35 sites in the upper estuary in November.

5) **Delta Resident Shoreline Fish Monitoring:** Since 1995, the IEP has conducted biennial electrofishing surveys of shoreline habitats in the Delta to monitor trends in abundance of resident fishes and assess species/habitat associations. Sampling is conducted at 20 fixed sites every other month from February through August. This sampling program will be incorporated in the monitoring program. The program will be expanded to sample areas in and around riparian habitat restoration sites in the Delta as needed..

6) **Estuarine Shallow-water Habitat Fish Monitoring:** The ERPP includes many ecological zone targets relating to the creation of shallow water habitats in the estuary. These habitats are expected to provide benefits for the estuary's fish community. Also, the fish communities which develop in these new habitats are an important indicator of habitat quality and function. The monitoring plan will include an evaluation of the need for and as appropriate, the design and implementation of a program of routine fish monitoring in shallow water habitats (tidal marshes, shoals, etc.) in the upper estuary. This will enhance existing large-scale fish monitoring efforts which are conducted primarily in open waters, which may provide biased indications of the seasonal and annual abundance of some species.

7) **Adult Striped Bass Population Parameter Monitoring:** Information from the IEP biennial large-scale capture and tagging of adult striped bass for the purpose of making mark-recapture estimates of abundance, age distribution, and mortality rates will be incorporated into the monitoring program. This information is critical for responsible fishery management and assessing the recovery of the estuary's most economically important recreational fishery. IEP's existing mark-recapture effort is recommended by CVPIA-CAMP to assess progress towards CVPIA-AFRP striped bass adult population targets.

8) **Sturgeon Year-Class Strength Monitoring:** There will be cooperation with IEP and DFG to continue sturgeon year-class strength monitoring and incorporate its results in the monitoring program. This program consists of annual otter trawl and baited set-line sampling in San Pablo and Suisun bays and the Delta, targeting 12- to 36-inch sturgeon. The resulting data provides an index of juvenile sturgeon year-class strength that can be related to environmental factors.

9) **Adult Sturgeon Population Parameter Monitoring:** The monitoring program will incorporate information from IEP's existing program of adult sturgeon population monitoring. This monitoring consists of periodic (every 2 to 4 years) collection, tagging and release of legal-sized sturgeon. Recaptures in subsequent sampling efforts and from the sport fishery are used to estimate abundance, age distribution, and mortality rates to set and assess angling regulations, and assess population responses to environmental conditions.

10) **U.C. Davis Suisun Marsh Fisheries Monitoring:** The monitoring program will incorporate information from UC Davis' program of fish sampling in the Suisun Marsh, Solano County. This program is designed to monitor long-term changes in the distribution and abundance, and of fish populations within the Marsh particularly as they relate to Salinity Control Structure operations and other Marsh management efforts. Sampling has been conducted for almost 20 years and includes monthly sampling at 17 trawl locations and one beach seine site.

11) **CVP/SWP Export Facility Fish Salvage Monitoring:** The USBR and DWR, in cooperation with DFG, continuously monitor fish salvage rates at the CVP and SWP export facilities in the Delta. Salvage data is important as both an indicator of export facility impacts on delta fish populations and as an indicator of species abundance and distribution. Salvage monitoring is also a critical component of CALFED Operations Group ("real-time") monitoring effort. There will be cooperation with USBR and DWR to ensure that salvage monitoring continues.

KEY FOCUSED RESEARCH TOPIC AREAS:

1) Delta smelt life history, habitat use, and controlling environmental factors to better target and assess restoration and protection efforts.

2) Splittail life history, habitat use (particularly spawning habitat requirements), and controlling environmental factors

3) Continued assessment of environmental factors controlling striped bass production and adult abundance

4) The role of shallow-water habitats (i.e. tidal marshes, shoals, shaded littoral habitat, etc.) in Bay-Delta fish production

5) Sampling bias and effectiveness associated with existing, major monitoring programs

6) Methods for estimating young-of-the-year sturgeon abundance and distribution

7) Ecological effects of introduced fish and invertebrate species

8) Examination of existing fish egg and larva data to determine the need for and scope of future E&L sampling

9) Inclusion of estuarine fisheries data in a comprehensive, integrated analysis of past and future Bay-Delta monitoring data to provide a broader, ecosystem based view of Bay-Delta system status and trends, and to direct future monitoring efforts.

10) Opportunities for integrating estuarine fisheries monitoring with other types of Bay-Delta ecosystem monitoring

11) Abundance, distribution, and ecological efforts of recently introduced crab species

12) Harvest and survival of largemouth bass in the Delta

13) Efficiency of combining or integrating IEP's fall mid-water and Bay trawl surveys

14) CVP and SWP fish salvage facility efficiency studies for species other than striped bass, salmon, and steelhead

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Central Valley Chinook Salmon and Steelhead Monitoring

SUB-PROGRAM PURPOSE: To monitor key population and habitat use parameters for all races and runs of Central Valley chinook salmon and steelhead for purposes of documenting abundance trends and life stage-specific responses (distribution, abundance, growth, survival, etc.) to habitat restoration efforts and management actions. To be effective the monitoring program must coordinate among the resource agencies, the Interagency Ecological Program's Central Valley Salmon Team, the CVPIA's Comprehensive Assessment and Monitoring Program, and stakeholder programs on individual streams.

SUB-PROGRAM ELEMENT DESCRIPTIONS:

ADULT ABUNDANCE

Estimates of adult abundance in any given year is a combination of estimates of the number of fish harvested, the numbers of fish reaching the spawning grounds and the numbers entering the hatcheries. Adult chinook salmon are harvested in the ocean by commercial and recreational fisheries and in an inland recreational fishery, whereas adult steelhead are only harvested in the inland recreational fishery. Those adults not harvested in the fisheries can spawn naturally in the streams or return to hatcheries for artificial spawning. Estimates of harvest, in-river spawning and hatchery returns are needed to determine annual indices of adult abundance.

1) **Annual instream spawner abundance estimates:** These estimates, also called "escapement", will be obtained from selected Central Valley streams including:

- Mainstem Sacramento River above Red Bluff Diversion Dam
- Mainstem Sacramento River between Princeton and RBDD
- Battle Creek
- Big Chico Creek
- Clear Creek
- Mill Creek
- Deer Creek
- Butte Creek
- Feather River
- Yuba River
- Bear River
- American River
- Mokelumne River
- Stanislaus River
- Tuolumne River
- Merced River

Survey methods will use best available technology and will vary by stream. The following techniques are now being used:

- Direct counts of adults ascending ladders
- Mark-recapture of adult carcasses on the spawning ground
- Aerial counts of redds
- Snorkel surveys

2) **Annual estimates of number of adults entering hatcheries:** Hatchery staff at the Coleman National Fish Hatchery, the Feather River Hatchery, the Nimbus Hatchery, the Mokelumne River Hatchery and the Merced Fish Facility will provide estimates of total (adults plus grilse) chinook salmon and steelhead taken into the hatcheries each year.

3) **Annual estimates of ocean and inland harvest:** Ocean harvest will estimated by a field sampling program designed to sample about 20 percent of the harvest. This program, which consists of intensive dockside sampling, will also be used to collect coded-wire or other tags and marks used in hatchery evaluations and other tagging studies. Random stratified inland angler surveys will be conducted and harvest estimates obtained from the recreational fisheries in key streams and the estuary. As with the ocean harvest surveys, inland harvest monitoring will also be used to recover tags applied to hatchery and wild salmon and steelhead.

JUVENILE ABUNDANCE

1) **Instream sampling:** Annual out migrant sampling in the following 11 selected stream sites from January through June will be conducted:

- American River near Watt Avenue
- Battle Creek near mouth
- Big Chico Creek near mouth
- Butte Creek at Parrott-Phelan Dam
- Clear Creek near mouth
- Feather River near Live Oak
- Merced River
- Mokelumne River at Woodbridge Dam
- Stanislaus River near Caswell
- Tuolumne River
- Yuba River near Hallwood Avenue

In addition to those sites juvenile monitoring will occur in the upper Sacramento River near the RBDD and at the confluence with Cow Creek and from September 1 through June 30 at the upper dams in Mill and Deer creeks.

The juvenile sampling will be by use of rotary screw traps. The objective is to determine outmigration timing and condition of juvenile outmigrants and to develop annual estimates of the numbers of juveniles leaving major salmonid producing watersheds.

2) **Estuarine monitoring:** This element will monitor the timing and abundance of juvenile chinook salmon entering and leaving the Delta at sites on the lower Sacramento and San Joaquin rivers, within the Delta, and at Chipps Island or other appropriate locations downstream of the Delta. Gear type will vary by site and include Kodiak trawling, mid-water trawling, rotary screw trap and beach seines. Estuarine sampling will also be used in specific experiments to evaluate the effects of various restoration and management actions on juvenile salmonid survival in the rivers and through the estuary.

3) **Fish salvage monitoring:** This salmonid sub-program assumes that the routine salvage monitoring at the State and federal Delta fish facilities will continue. Funding for these efforts will be from the Bureau of Reclamation

and the Department of Water Resources.

HABITAT MONITORING

Other sub-program elements (Basic Water Quality, River Morphology, Riparian Habitat, River and Estuarine Channel Flow) are designed to provide information on variables that may affect salmon distribution and abundance. In addition, Fish Community and Benthic Invertebrate sub-programs will provide information on important biological variables (for example potential predators, competitors and food supply) that may affect juvenile salmonid survival and growth.

COMPREHENSIVE TAGGING AND MARKING PROGRAM

About 30 million chinook salmon smolts and about two million steelhead yearlings are released from Central Valley hatcheries each year. Effective management of salmonid stocks, as well as assessing the effectiveness of restoration actions, requires that biologists and managers have a better understanding of the contribution of hatchery production to harvest and escapement. To obtain this understanding the recommended monitoring program includes a constant fractional marking program for hatchery chinook salmon releases and a total marking program for steelhead releases. The marking program may consist of tagging (for example, coded wire tagging) or simple marking such as fin clips. There are 15 distinct release strategies for Central Valley hatchery chinook and each strategy requires a distinctive mark.

The marking program will result in many more tagged salmon being released into the rivers and the estuary than has been seen in the past. Marking and releasing are only the first parts of the total package. Provisions must be made to: recover the tags in the fisheries, on the spawning grounds and in the hatcheries; determine their origin; and make the information available to interested parties. The harvest, escapement, and juvenile sampling will be used to collect the tags and additional resources will be devoted to reading the large numbers of tags that will be recovered and making the data available through an electronic data system.

KEY FOCUSED RESEARCH AREAS:

Although not an exhaustive list, the following are some areas of research that will increase our understanding the effects of alternate management and restoration efforts.

1) Develop and evaluate improved methods to estimate spawner abundance.

2) Salmon life cycle models for individual races and drainage areas.

3) Continue developing methods to distinguish Central Valley salmon and steelhead races.

4) Mark sufficient numbers of wild (naturally produced) juvenile salmon to determine effects of environmental conditions on their growth and survival.

5) Determine the importance of various habitat types in the lower river and estuary to success of individual salmon year classes.

6) Develop new techniques for assessing the survival of juvenile chinook salmon during their movement to the ocean.

7) Develop methods for evaluating the impacts of ocean conditions on success of individual year classes.

8) Assess the impacts of diversions on salmon survival.

9) Evaluate the use hydro acoustics, radio tags, acoustic tags and other techniques to develop a more thorough understanding of how juvenile and adult salmonids move in relation to flows, flow splits, and barriers.

10) Continue evaluations of the effects of water project operation, flows, barriers and ambient

environmental conditions on survival of juvenile salmon in the south Delta.

11) Evaluate impacts of hatchery stocking practices on wild runs and means of reducing or eliminating any adverse impacts.

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Inland Sport fishery Surveys

SUB-PROGRAM PURPOSE: To monitor inland sportfishing effort and harvest to provide for 1) informed sportfish species management and provide, and 2) the assessment of sportfishing opportunity quality and quantity.

SUB-PROGRAM ELEMENT DESCRIPTION: The following is a brief description of the Sport fishery survey program now being developed by CVPIA-CAMP in cooperation with the IEP and DFG's Inland Fisheries Division. Cooperation with these entities to design and implement an integrated Sport fishery survey program that meets the information needs of all parties is expected. The CVPIA population goal for anadromous fish is to increase the level of natural production of anadromous species in the Central Valley to at least twice the average estimated during the baseline period 1967-1991. Species include chinook salmon, steelhead, American shad, striped bass, white sturgeon, and green sturgeon. The program seeks to restore beneficial uses of the Bay-Delta system, including sportfishing opportunities.

CVPIA-CAMP's first objective is to assess the overall (cumulative) effectiveness of actions implemented to reach the doubling goal. The assessment requires summing each of the major production components including spawning escapement of chinook salmon, inland and Ocean sport catch and commercial catch of salmon; inland sport catch of steelhead; adult striped bass abundance in the Bay and Delta; adult sturgeon abundance in Suisun and San Pablo bays; and American shad abundance (an index based on captured juveniles in the lower major rivers). In addition, progress towards the habitat restoration implementation objectives requires monitoring of the sport catch of all other fish species supporting a significant fishery.

The sport catch for the inland areas would be determined by an angler survey of the in-river harvest and the downstream harvest in "target" watersheds such as the Sacramento River above the Feather River, the Sacramento below the Feather (also Feather, Yuba, American rivers); and San Joaquin River below Vernalis (also Stanislaus and Mokelumne rivers), and major embayments in the upper estuary.

Anglers will be interviewed by roving clerks in boats to produce estimates of angler use and sport harvest; these results will lead to monthly estimates and annual harvest summaries for salmon and steelhead. All species observed in the "creels" will be identified and measured, including other anadromous species and non anadromous species such as centrarchids. The angler survey information will be useful to augment population estimates for the other anadromous species listed above; however, population estimates for these other species will be developed through currently ongoing programs carried out by IEP participants or other.

All species will be examined for fin clips, and heads will be removed from adipose-clipped fish for recovery of coded wire tags.

The sampling schedule will be determined randomly, stratifying week days and weekend days, and randomly selecting a start time and location. The method of operation will be to run by boat, a randomly selected sampling section at high speed recording angler use, and then systematically interview a representative sample of anglers.

Data will be summarized in a standardized format and transmitted monthly or quarterly to the database now being established with IEP. It is anticipated that the angler survey will be

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conducted by DFG's Inland Fisheries Division.

MONITORING PROGRAM SUB-PROGRAM DESCRIPTION

SUB-PROGRAM: Monitoring Data Management and Dissemination

SUB-PROGRAM PURPOSE: Data collected for the Ecosystem Restoration Program will:

1) help determine if the Ecosystem Quality Objectives are being met,

2) determine if the monitoring program needs to be refined, and

3) provide data for technical analysis and reports.

The Program Data Management and Dissemination System will be developed in cooperation with IEP to fulfill these tasks by providing data to all interested parties in a readily usable format. This data system will be based on a relational database management system accessible through the Internet.

SUB-PROGRAM DESCRIPTION: Data from the various general ecosystem monitoring sub-programs and action-specific evaluations will be transferred from data collectors to IEP information technology staff. These data will be error checked and loaded into the IEP relational database. Data transfers will be accomplished using a variety of technologies including: FTP, ODBC, FAXes, E-mail etc. A database administrator will monitor data transfers and IEP QA/QC guidelines for data loading and management will be followed.

The relational database management system will run on a mini-computer workstation using the Solaris operating system and a T-1 communication link is used to provide quick Internet access to the data. The RDBMS will include an interface that will assist users with specifying the data they need. The RDBMS relates diverse types of information collected by the monitoring program and will enable users to retrieve information using a simplified query system.

Additionally, reports and model output can be presented on the server to help evaluate the Bay-Delta alternatives. Increased access to data reports will improve the overall Ecosystem Restoration Program.

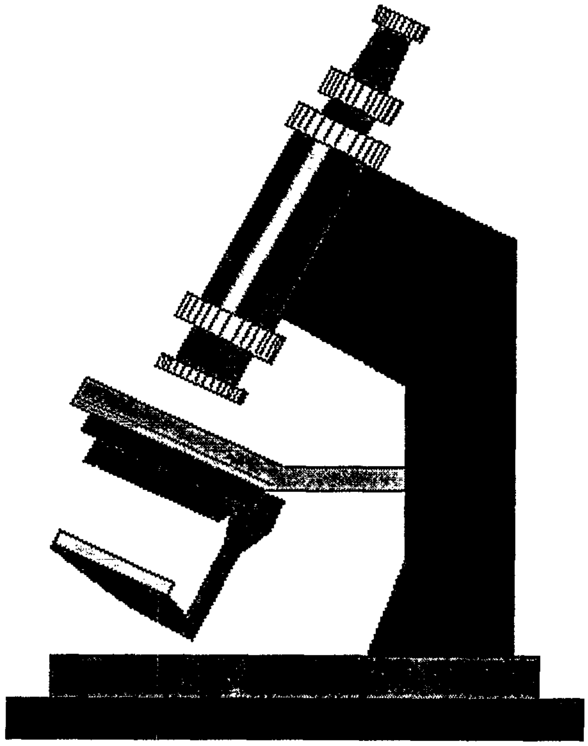
Database users will require a computer, an Internet provider, and browser software (such as Netscape, Explorer etc.). IEP's Internet (homepage) address is www.iep.ca.gov.

KEY FOCUSED RESEARCH TOPIC AREA:

The IEP is evaluating several types of software including five types of RDBMS software (Oracle, Sybase, Ingres, Postgres and Ilustra). In addition, software will be evaluated to determine the most effective user interface before purchasing. Staff will evaluate these software based on the following criteria:

- Database engine storage features for field data, text files and maps
- Front end tools that can be used to create user interfaces for the database engines
- back end tools to determine which output data in a format needed by IEP data users
- hardware needed to support each database system
- staff time required to build and maintain the data bases
- vendor support
- overall cost

Input from the IEP Data Utilization Work Group and Project Work Teams, CVPIA/CAMP staff and other Bay-Delta groups will be used to refine the RDBMS products.



INTRODUCTION

Focused Research = The use of the experimental method to answer specific questions.

To develop a better understanding of Bay-Delta ecological processes, CALFED requested that a list of focused research items be developed. This short list is the first draft product resulting from that request. This list is the culmination of responses from 13 individuals (of 45 originally asked, ~29% response rate), and from documents recently prepared that in some form addressed the subject of research questions. These documents are Research Recommendations for the San Francisco Estuary prepared by the San Francisco Estuary Institute and Working Conceptual Model for the Food Web of the San Francisco Bay/Delta Estuary prepared by the Interagency Ecological Program's Estuarine Ecology Team. Also, appropriate research questions identified in the draft Ecosystem Monitoring document currently being prepared for CALFED by the IEP are included here.

The list of research topics included in this draft document has not been prioritized. However, it is believed that most are important enough to warrant work starting on them within at least 5 years. In some cases, work has already started on some. This draft list should also not be considered inclusive. Many important research questions are not included and should be added.

This document is far from final and needs to be reviewed and modified by appropriate Project Work Teams of the IEP, by the IEP's Science Advisory Group, and by other organizations such as the San Francisco Estuary Institute and CVPIA/CAMP. The draft document should be considered a strawman so direct and focused input can be provided by other groups to develop a more comprehensive and complete final.

RESTORATION -- SHALLOW WATER/WETLAND DEVELOPMENT

Restoration of delta islands to shallow water habitat and development of wetlands are major CALFED objectives. While restoration carries the connotation that "good" habitat will be created, there is much uncertainty about their natural structure and function. A basic understanding of the relationships among the physical landscape, hydrology, sediment flux and biota need to be understood in order to guarantee some degree of success in restoration objectives. In some cases, it may just be necessary to develop restoration projects in several areas of the delta and carefully monitor the results for several years. This would help identify which regions and types of restoration projects would be most successful.

Some general questions associated with understanding the benefits and natural progression and succession of restored habitats and wetlands include:

- How much of what kinds of restored habitat do we want and where? What conditions indicate health of these restored habitats?
- What are the relationships among the physical landscape, hydrology, sediment flux and biota?
- What are the interrelationships among shallow water and wetland components, population and community ecology, endangered species, ecology and control of exotic species in restored habitats?

Some focused research questions associated with restoration projects include:

- Develop a sediment mapping program for Delta channels coupled with a time series of suspended sediment concentrations and bedform movement. This would provide information for calculating sediment supplies in different reaches of the delta and for predicting topographical changes for restoration projects.
- Develop a program to document the movement of pesticide-laden sediments from their sources through the Delta. This information would help decide when and where to avoid harvesting channel sediments for island restoration.
- Develop a study which assesses the benefits of shallow water habitat to various species over various life stages. The question being asked here is simply, how is shallow water habitat being used by fish and wildlife?
- Compare species use associated with different types of habitat within a restoration project (shallow, non-shallow, wide deep channel, small narrow channel, vegetated perimeter, etc).
- Assess the potential impacts of shallow water habitat by studying the flow and/or water quality factors influencing the recent increases in higher aquatic weed production in the Delta.
- Determine the rates of compaction and decomposition of organic soils buried by or amended with mineral soils. Recovery rates of restored Delta islands to sea levels are dependent upon such rates.
- Develop a field-scale program that simultaneously assess the hydrologic and water quality effects (chemical composition and loads of organic carbon) resulting from changes in water and land use on Delta islands. The information would be useful in judging the feasibility of restoring Delta islands to wetlands.
- Develop a follow-up program to determine the response of the biological community to recent Bay-Delta restoration programs and other conditions such as the natural flooding of islands, including those at Donlon Island, Venice Cut Island, Cache Slough, etc.

ECOSYSTEM PRODUCTIVITY

One of CALFED's goals is to restore the estuary to a productive system that supports major aquatic resources and habitats. The question to be answered here is, "How does the Bay-Delta ecosystem function?" Questions associated with this are:

- What are the sources and processes controlling water chemistry in general, and plant nutrient dynamics (sources and sinks) in particular?
- What are the factors affecting the stimulation of primary production?
- What are the factors that control the distribution and productivity of algal and zooplankton biomass in the estuary?
- How are the food chains of the estuary

structured? What are the links between primary production, higher trophic levels and fish abundances?

- What mechanisms (direct or indirect) cause covariation of the abundance of estuarine resident species with delta outflow or X2?

Given the inherent variability of conditions continuously affecting estuarine processes (climatic changes, hydrology, chemistry, introduced species, contaminants, etc.), this is not an easy task. However, some degree of understanding can be obtained by partioning large, sweeping questions into focused research proposals. Examples of such focused research questions are listed below.

- Measure the production of phytoplankton and particulate organic carbon from existing riverine shallow water habitats, main channel areas, and restored habitats over several parts of the estuary (tidal freshwater, brackish/entrapment zone, and lower bays) to better understand how the system functions.

- Study the importance of organic matter's input to the estuary, possibly transferred to zooplankton through the uptake by particle-bound bacteria and grazing on these particles by zooplankton. This information is needed when establishing management actions focused on boosting productivity of lower trophic levels.

- Create a food web model that would include all the major components and determinations (by literature synthesis or measurement) of growth rates and biomass of abundant species or groups in the area. (This study may require a monitoring component to validate and modify it on a continuous basis).

- Using food web model results plus historical patterns of abundance and introductions, determine how productivity of the estuary has changed over time with the various alterations of the flow regime, and introduced species.

- Determine effects exchanges between channels and shoals have on phytoplankton, zooplankton, larval fish and benthos.

AQUATIC RESOURCES

One of the fundamental questions associated with the management of aquatic resources is:
How are populations of fish in the Delta and Bay regulated? What is the importance of recruitment, feeding and food supply in early life, predation, export losses, density- dependent mechanisms, outflow and exposure to contaminants?
This question is fundamental for managing fish populations, yet, it is very general and would require a tremendous effort to answer, even for one species. However, answers to some of these questions would enable managers to target the most sensitive life stages for management activity, reducing the necessity for broad-scale activities such as season long high outflows. The focused research questions below address some of these issues.

Many of the focused questions relate principally to chinook salmon. This is what was submitted during the informal survey. Focused research questions still need to be developed for a number of species including delta smelt, longfin smelt, splittail, green sturgeon, Sacramento perch, flounder, crabs, shrimp and others.

- How can we effectively sample shallow-water, side-channel, mid-channel and open-water habitats to eliminate sampling bias and distributional effects?

- What are the differences in trophic structure, predator-prey relationships and growth of juvenile and larval fish between vegetated land-margin habitat and open water land-margin habitat?

- How does particle residence time differ between vegetated land-margin habitat and open water land-margin habitat?

CHINOOK SALMON

- What is the influence of reverse flows on salmon migration through the Delta?
- What is the influence of pulse flows to salmon survival?
- Why is salmon survival so low in the south Delta?
- Develop and evaluate improved methods to estimate spawner abundance.
- Develop salmon life cycle models for individual races and drainage areas.
- Mark sufficient numbers of wild (naturally produced) juvenile salmon to determine effects of environmental conditions on their growth and survival.
- Determine the importance of various habitat types in the lower river and estuary to success of individual salmon year classes.
- Develop new techniques for assessing the survival of juvenile chinook salmon during their movement to the ocean.
- Develop methods for evaluating the impacts of ocean conditions on success of individual year classes.
- Assess the impacts of diversion on salmon survival.
- Evaluate the use of hydroacoustics, radio tags, acoustic tags, and other techniques to develop a more thorough understanding of how juvenile and adult salmonids move in relation to flows, flow splits, and barriers.
- Continue evaluations of the effects of water project operations, flows, barriers and ambient environmental conditions on survival of juvenile salmon in the south Delta.
- Evaluate impacts of hatchery stocking practices on wild runs and means of reducing or eliminating any adverse impacts.
- Assess the role of fry rearing in the Delta. Study otolith samples from salmon collected in different delta habitats to see how salmon use the Delta and which habitats result in better growth.
- Determine the significance of flooding in Yolo Bypass to salmon fry and smolts in terms of survival.

DELTA SMELT

- Determine growth rates of larval and juvenile delta smelt caught in various rearing habitats (shallow water, channels) in different areas of the estuary (Suisun Bay, Napa River, Delta).
- Determine through histopathological and genetic biomarker work if delta smelt exhibit symptoms of contaminant exposure.
- Determine habitat criteria for spawning smelt and specific spawning locations.
- Determine the applicability of using the particle tracking model to monitor movement of larval delta smelt.
- Determine which factors cause delta smelt to move downstream.
- Determine the diet of delta smelt and how it compares with food availability.
- Identify impacts of predation by inland silversides and other species.
- Identify impacts of competition with wakasagi and other species.

SPLITTAIL

- Determine how fecundity varies by age and size.

- Conduct tagging studies to estimate annual survival of different age and sex groups.

- Conduct scale and otolith studies to examine the age composition of the splittail population.

- Determine whether juvenile splittail reside in the Sacramento and San Joaquin rivers during the summer period.

STURGEON

- Develop methods for estimating young-of-the-year sturgeon abundance and distribution.

- Develop a sturgeon life-history model for the Bay-Delta.

CONTAMINANTS

It is well documented that elevated contaminant concentrations exist, for periods of time, in the estuary's water, sediment and biota. Some of the basic questions associated with contaminants are:

- Where do the various type of contaminants come from?

- What happens to contaminants (fate) once they enter the Bay-Delta system?

- Which contaminants cause biological damage to estuarine species?

One of the most important questions, that has been relatively poorly studied and is poorly understood is:

- What are the ecological effects of contamination?

Many of the focused research questions listed below attempt to address the more general questions as well as the question of ecological effects. However, as with the other focused research questions, the list is not complete and needs further development.

- Are water-soluble pesticides and metals causing disturbances at lower trophic levels (phytoplankton, zooplankton and benthos) thereby contributing to adverse effects on estuarine fish? What aspects of the fishery would be most vulnerable to such disturbances?

- Develop quantitative bioaccumulation models for *Potamocorbula* and/or other key species as a function of different bigeochemical conditions.

- Determine where various types of contaminants originate from. Consider land use types and wet or dry flow conditions. (Sources of copper, silver, mercury, selenium, and PCB's are of particular concern).

- Using histopathological and genetic biomarker methods, determine whether key species of estuarine fish are being affected by contamination exposure.

- Determine the cause of fathead minnow toxicity in the Sacramento River.

- Develop pilot-level water and sediment contaminant studies and conduct comprehensive literature reviews to determine appropriate sampling locations, frequency and contaminant constituents that should be included in a long-term monitoring program for the Bay-Delta.

- Develop a multivariate fish condition index that is biologically meaningful and easily conducted during routine fish sampling. Possible variables include lesions, tumors, condition factor, and simple blood tests. A fish condition index could be especially useful in assessing population level effects.

MERCURY

- What species in the estuary are most likely to be affected by mercury contamination and how or where is mercury focusing in the food web?

Conduct *in situ* bioaccumulation studies on various trophic levels. All major tributary inputs to the estuary should be included.

- Develop detailed mercury mass loading studies from the Central Valley to identify major sources. Existing studies need to be expanded.

- Watershed studies need to be conducted in all major mercury source areas to determine local bioavailability, since mercury exists in a number of different forms and not all appear to be equally bioavailable. The UCD bioindicator species could be used to expand the database for bioavailable mercury sources from throughout the Bay-Delta watershed.

SELENIUM

- Relate sturgeon population dynamics, diving duck (scooter) reproduction estimates and crab abundance levels with selenium exposures by monitoring of water, particulate and *Potamocorbula* tissue concentrations.

- Develop a better understanding of why reduced river inflows seem to increase selenium concentration in clams.

- Improve knowledge of how load inputs from different sources affect selenium speciation, and biogeochemical particle-water partitioning.

INTRODUCED SPECIES

The Bay-Delta estuary is now recognized by some researchers as the most invaded aquatic ecosystem in North America. There exists in the estuary, 212 species recognized as introduced and at least another 123 species considered as not clearly native or introduced. The basic question associated with these introductions is: What are the ecological impacts to the system by introduced species, and to what extent do they suppress or otherwise modify populations of native species? Some focused research questions associated with this general question are:

- What kinds and levels of disturbance, what habitat conditions, favor exotic species in the Bay-Delta system and how can these disturbances and unfavorable conditions be reduced to help natives remain viable?

- Determine to what extent *Potamocorbula* continues to suppress phytoplankton and zooplankton, and how other zooplankton species are able to thrive where the extant species have been suppressed. This could help us understand the ways in which the upper estuary has shifted from an ecosystem dominated by pelagic communities to one dominated by the benthos.

- Though zebra mussels have not yet been successfully introduced to this estuary, there is a high probability that they will be. Develop information on the potential ecological impacts that may occur in this estuary associated with their introduction, and identify strategies in their life history that may lead to successful control strategies once they are in the system.

- Develop information on control strategies that could be employed to restrict additional introductions through ballast water and other sources.

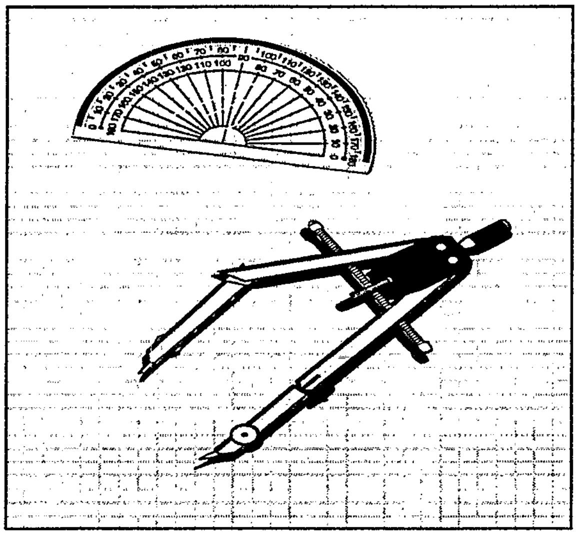
- Develop abundance, distribution and ecological effects information of the recently introduced green and mitten crabs.

ESTUARY MODEL DEVELOPMENT - HYDRODYNAMIC DATA DEVELOPMENT

- Create clear conceptual models of processes and mechanisms of the physical and biological components of the estuary. Submodels for valued components of the ecosystem (e.g. fish) and for supporting components (e.g. phytoplankton) are priorities.

- Create mechanistic models that accurately simulate and predict any of the numerous physical, chemical or biological processes of the estuary. Need to conduct requisite preliminary studies on carbon flow and trophic energy flow.

- Investigate the utility of obtaining flow data in the Delta by deploying an ADCP on the channel bottom at a selected monitoring location and attempt to relate the velocity profile data provided by the ADCP to tidal flow using a relationship developed from flow measurements made with the portable ADCP flow measuring system.



INTRODUCTION

Phased implementation is a logical approach to facilitate implementing actions identified in the ERPP. Phased implementation is comprised of a multivariate priority stragegy and an evaluation of critical pathways and action dependencies which assist in identifying and sequencing the implementation of the ERPP.

Phasing is ultimately influenced by the availibility of restoration funds throughout the duration of the program, individual and cumulative costs to implement the ERPP, and priority stragegies that select for specific actions to reach specific targets.

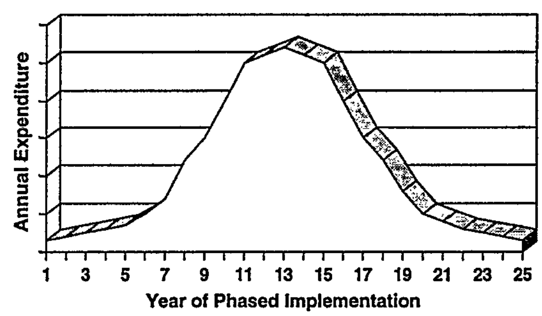
ASSUMPTIONS

Development of the proposed implementation strategy is based on a series of assumptions. These assumptions provide guidance and assist in developing a logical procedure for implementing the ERPP.

FUNDING

This strategy assumes that the $390 million available through Proposition 204 will become available after the CALFED Bay-Delta Program's final EIR/EIS is formally adopted by the CALFED agencies through the filing of a Record of Decision for the federal EIS and certification of the EIR by the California Resources Agency by late Fall 1998. It is assumed that these funds will be encumbered and spent during a 25-year period which provides a pro-rated fund availability of approximately $15 million per year. The projected expenditure of funds will likely follow a bell-shaped curve. This is necessary to develop the infrastructure needed for implementation, monitoring of indicators, focused research, and post project evaluations.
It is also assumed that expenditures in any single year will not be limited if suitable projects exist for implementation.

Phased Implementation Expenditures



Category III is assumed to have completed the expenditure of $120 million during the first five years on actions identified for early implementation.

Other sources of funding is also anticipated during the early implementation phase and is anticipated that an additional $426 million will be available through a series of federal appropriations.

ASSURANCES

We need to include any comments on assurances for phased implementation.

IMPLEMENTATION FOCUS AREAS

The geographic scope of the ERPP is defined by the interdependence and linkage of watersheds, streams, rivers and the Bay-Delta and the complex life histories of the dependent fish, wildlife and plant communities. The restoration of ecological processes requires implementation of actions throughout much of the Central Valley, its upper watersheds, the Bay-Delta, and near-shore ocean. The primary geographic focus is the Bay-Delta, the Sacramento River, the San Joaquin River, and their tributary watersheds directly connected to the Bay-Delta system below major dams and reservoirs. Secondarily, the ERPP addresses, at a programmatic level, the near-shore ocean, South San Francisco Bay, lower San Joaquin Valley, and the upper watersheds above the major dams.

The primary geographic focus area for the ERPP is divided into 14 zones, each characterized by a predominant physical habitat type and species assemblage. These 14 ecological zones constitute the geographic areas in which the majority of restoration actions will occur.

CUMULATIVE BENEFITS

Many projects proposed by the ERPP will be implemented simultaneously. In addition, other agencies are implementing restoration program, such as the Anadromous Fish Restoration and Anadromous Fish Screening programs aouthorized by the Central Valley Project Improvement Act. This will restrict the opportunity to develop evaluations of the ecological benefit from individual projects. In the long-term, this may be a minor problem, but in the short-term and early stages of the implementation program, the ability to judge the merits of single types of restoration actions is very important in providing information for adaptive management and the structuring of the longer-term program.

The ERPP assumes that monitoring programs will be developed as companion projects to provide the best possible assessment of the merits of individual projects.

IMPLEMENTATION INFRASTRUCTURE

Refinement and implementation of the programmatic actions identified identified in the ERPP will require and extensive agency infrastructure. Major components of this infrastructure include project development, engineering analysis and design, environmental permitting, construction, construction oversight, contract administration, and post-project evaluations. It is assumed that the early years of implementation will be constrained until the infrastructure is fully developed.

IMPLEMENTATION STRATEGY

The implementation stragegy for the ERPP is comprised of many component parts. These include strategies for the following (incomplete):

- levee setbacks and floodplain improvement
- unscreened diversions
- fish passage
- riparian and riverine aquatic habitat restoration
- contaminants
- water acquisition
- land acquisition and conversion to habitat
- control of invasive organisms (plant and animal)
- sediment supply
- temperature control
- harvest, and

- other elements.

Each component part has a variable approach to phased implementation and differing ranking criteria for project consideration.

STRATEGY FOR WATER ACQUISITION

The strategy for water acquisition is a very important part of the ERPP. Water is actively being sought through a variety of other State and federal programs such as the State Water Bank and Central Valley Project Improvement Act. The ERPP strategy is closely linked to these existing programs. [This needs to be greatly expanded.]

STRATEGY FOR LAND ACQUISITION AND CONVERSION TO HABITAT

The strategy for land acquisition lands in the Sacramento-San Joaquin Delta and Suisun Marsh for conversion to various types of aquatic or tidally influenced habitats includes the development of conservation easements or the direct acquisition of lands from willing sellers. Lands under consideration must be suitable to conversion to the following:

- TIDAL PERENNIAL AQUATIC HABITAT in the Sacramento-San Joaquin Delta or Suisun Marsh/North San Francisco Bay Ecological Zones;
- NONTIDAL PERENNIAL AQUATIC HABITAT in the Sacramento-San Joaquin Delta or Suisun Marsh/North San Francisco Bay Ecological Zones;
- SALINE EMERGENT WETLANDS in the Suisun Marsh/North San Francisco Bay Ecological Zone;
- FRESH EMERGENT WETLANDS in the Sacramento-San Joaquin Delta Ecological Zone;
- SEASONAL WETLANDS in the Sacramento-San Joaquin Delta or Suisun Marsh/North San Francisco Bay Ecological Zones;
- PERENNIAL GRASSLANDS in the Sacramento-San Joaquin Delta or Suisun Marsh/North San Francisco Bay Ecological Zones; and
- AGRICULTURAL LANDS in the Sacramento-San Joaquin Delta Ecological Zone.

STRATEGY FOR SETBACK LEVEES AND FLOODPLAIN IMPROVEMENT PROJECTS

The strategy for setback levees and floodplain improvement projects is to closely coordinate potential actions with the CALFED levee system intergrity common program. This program is directed at levees and channels in the Sacramento-San Joaquin Delta Ecological Zone. The strategy also includes close coordination with the Governor's Flood Control Task Force, the Corps of Engineers Sacramento River flood control program and others.

The strategy includes efforts to assist in setting program and project priorities for these other programs for the purpose of moving ecologically beneficial projects to the forefront.

STRATEGY FOR UNSCREENED DIVERSIONS

The strategy for reducing the adverse impacts of unscreened diversions in the Central Valley is to closely coordinate restoration projects with the Department of Fish and Game, the U.S. Fish and Wildlife Service, and the National Marine Fisheries Service. The Department of Fish and Game has legal authority under the Fish and Game Code to install or require diverters to install positive barrier fish screens on diversions. The U.S. Fish and Wildlife Service is required under Section 3406(b)(21) of the Central Valley Project Improvement Act (CVPIA) to "assist the State of California in efforts to develop and implement measures to avoid losses of juvenile anadromous fish resulting from unscreened or inadequately screened diversions on the Sacramento and San Joaquin Rivers, their tributaries, the Sacramento-San Joaquin Delta, and the Suisun Marsh. Such measures shall include but shall not be limited to construction of screens on unscreened diversions, rehabilitation of existing screens, replacement of existing non-functioning screens, and relocation of diversions to less fishery-sensitive areas."

The Department of Fish and Game has statutory responsibility for unscreened diversions and has an existing unscreened diversions program and staff. The U.S. Fish and Wildlife Service is authorized under the CVPIA to assist the State and has an Anadromous Fish Screening Program and staff. The CALFED strategy is to provide whatever assistance or support these agencies need to fully implement their respective programs as soon as possible.

STRATEGY FOR FISH PASSAGE

The strategy to improve fish passage in the ERPP Study Area is to closely coordinate potential actions with the Department of Fish and Game, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Bureau of Reclamation, local watershed conservancies, landowners, and other interest groups.

A relatively small number of fish passage barriers exist and the strategy includes the development of a timeline to completely resolve these stressors.

STRATEGY FOR RIPARIAN AND RIVERINE AQUATIC HABITAT RESTORATION

Riparian and riverine aquatic habitats are a very important ecosystem element that is found in every ecological zone and most ecological units. The strategy has several component parts: development of conservation easement, acquisition of land from willing sellers, cooperative programs with local landowners, and incorporation of measures to enhance or restore riparian communities in conjunction with other restoration projects such as set back levees, and floodplain restoration programs.

The strategy also include close coordination the the Upper Sacramento Sacramento River Fisheries and Riparian Habitat Advisory Council which seeks to restore riparian habitat along the Sacramento River between Red Bluff Diversion Dam and Colusa.

It also include close coordination the the U.S. Fish and Wildlife Service which is directed by Section 3406(b)(1)(A) of the CVPIA to protect and restore natural channel and riparian habitat values.

STRATEGY FOR CONTAMINANTS

The strategy for contaminants includes close coordination with the CALFED water quality common program. This program has developed strategies for mine drainage, urban and industrial runoff, municipal and industrial wastewater, agricultural drainage, and other elements in the Sacramento Basin, San Joaquin Basin, and Sacramento-San Joaquin Delta.

The ERPP strategy is to assist this program in those water quality areas that would provide substantial improvements in the health of aquatic resources, particularly for listed species and andromous fish.

STRATEGY FOR CONTROL OF INVASIVE ORGANISMS

The strategy for the control of invasive aquatic plant, invasive aquatic organisms, invasive riparian and salt marsh plants, and non-native wildlife is to fully cooperate and coordinate with existing control and research programs. Cooperating agencies include the U.S. Department of Agriculture, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, California Department of Water Resources, California Department of Fish and Game, State Water Resources Control Board, California Department of Food and Agriculture, California Department of Health Services, and numerous nonprofit organizations, societies, land trusts, and private landowners.

The strategy is to participate in the priority setting processes and to support control programs and control measures that will contribute to the

CALFED mission of improving ecological health of the Bay-Delta system and improve the beneficial uses of water.

STRATEGY FOR SEDIMENT SUPPLY

The strategy for restoring or enhancing natural sediment supplies to Central Valley rivers and streams and the Delta is to develop cooperative programs with the aggregate resource industry for the purpose of relocating gravel extraction activities to areas away from the active stream channel.

The strategy also include assessment of areas where natural sediment supply cannot be restored and developing collaborative programs to artifically supplement sediment and gravel supplies.

The strategy to improve natural sediment supplies along the major rivers such as the Sacramento River is closely linked to maintaining or restoring the meander zone and allowing natural erosion of streambanks to provide a continual supply of sediment to the system.

This strategy includes close coordination with the U.S. Fish and Wildlife Service which is required by Section 3406(b)(13) of the CVPIA which requires the development and implementation of a continuing program for the purpose of restoring and replenishing, as needed, spawning gravel lost due to the construction and operation of Central Valley Project dams, bank protection projects, and other actions that have reduced the availability of spawning gravel and rearing habitat in the upper Sacramento River from Keswick Dam to Red Bluff Diversion Dam and in the American and Stanislaus River downstream of Nimbus and Goodwin Dams, respecitvely.

STRATEGY FOR STREAM TEMPERATURES

The strategy for improving stream temperatures is through four elements: structural temperature control devices on large reservoirs, water management operations to conserve the cool water pools, long-term protection and restoration of riparian and riverine aquatic habitats, and control of agricultural and other warm water discharges.

STRATEGY FOR HARVEST

The strategy for harvest has two elements: develop better management data and increase wildlife enforcement efforts directed at reducing illegal harvest.

The strategy section is incomplete.

PRIORITY SCHEMES

The purpose of the ERPP is to implement remedial measures to improve ecological processes, habitats, and species which ultimately contribute to the CALFED long-term goal of restoring ecological health and improve water management for beneficial uses of the Bay-Delta system. Each ecosystem element has a discreet implementation objective that is fixed through time. Each ecosystem element has one or more targets and numerous programmatic actions designed to help meet the target level and hence the implementation objective.

There are innumerable pathways to select actions for implementation. The following considerations are relevant to developing selection criteria for implementing the ERPP.

CALFED SOLUTION PRINCIPLES

In designing a program to develop a long-term comprehensive plan that will restore ecological health and improve water management for beneficial uses in the Bay-Delta system, CALFED has developed the following solution principles. These principles can be applied to the selection process for each category in the ERPP phased implementation program.

The solution principles include the following:

- **REDUCE CONFLICTS IN THE SYSTEM**-- a solution will reduce major conflicts among beneficial users of water. A solution should significantly reduce each of the four major conflicts which have been identified for the Bay-Delta system. Most of the problems are embodied in the following conflicts: fisheries and diversions, habitat and landuse/flood protection, water supply availability and beneficial uses, and water quality and land use.

- **EQUITABLE** -- an equitable solution will focus on solving problems in all problem areas. Improvement for some problems will not be made without corresponding improvement for other problems.
- **AFFORDABLE** -- an affordable solution will be one that can be implemented and maintained within the foreseeable resources.
- **DURABLE** -- a durable solution will have political and economic staying power and will sustain the resources it was designed to protect and enhance.
- **IMPLEMENTABLE** -- an implementable solution will have broad public acceptance, legal feasibility and will be timely and relatively simple to implement compared with other alternatives.
- **NO SIGNIFICANT REDIRECTED IMPACTS** -- a solution will not solve problems in the Bay-Delta by redirecting significant negative impacts, when viewed in its entirety, in the Bay-Delta or other regions of California.

RANKING OF ECOSYSTEM ELEMENTS

The ERPP is structured to restore ecological processes that create and maintain habitats that support important fish, wildlife, and plant species. Restoring these ecosystem elements also includes reducing or eliminating stressors that impair their health. This provides a basis for relative ranking of the importance of ecosystem elements:

RELATIVE RANKING OF ECOSYSTEM ELEMENTS

First:	Restoration of ecosystem processes.
Second:	Restoration of habitats.
Third:	Restoration of species.

ECOSYSTEM PROCESSES

Restoration of ecosystem processes will likely be directed at reducing or eliminating stressors that impair healthy processes. Many ecological processes are highly constrained due to development projects such as urbanization, dam construction, and water management operations. For example, Shasta Dam on the Sacramento River has been in place for over 50 years. The natural sediment supply in the section between Keswick Dam and Red Bluff Diversion has been greatly reduced as a result. Removing Shasta Dam fails to meet the CALFED solution principles. Removal would not reduce conflicts in the system, would not be equitable in solving problems in all areas, and would cause significant redirected impacts. Therefore, alternatives to improving sediment supply in the Sacramento River below Keswick Dam must consider gravel supplementation programs and programs to increase the natural input of sediments from other sources.

HABITATS

Many habitats are created and maintained by healthy ecosystem processes such as streamflow, natural sediment supply, stream meander corridor, stream temperatures, and natural floodplain and floodplain processes. Restoration of habitats will first evaluate the potential of restoring the related ecosystem processes. Subsequent habitat restoration measures will be designed to fill the gaps remaining from inadequate processes.

Species

Species restoration measures will be the result of a three-step process: quality of ecosystem processes, quality of habitat, and identification of stressors that directly impair the species under consideration.

Species priorities will be based on health of the populations. Formally listed species will have a higher ranking that candidate and species of special concern, and depleted species will have a higher ranking than more abundant species.

Consideration of Threatened and Endangered Species

Restoration of State and federally listed endangered species is an important result of implementing the ERPP. In most priority schemes, additional weight will be given to actions that directly benefit listed species. These actions will include improvement or restoration of ecological processes such as streamflow and stream temperatures, recreation or improvement of habitat needed for migration, resting, foraging, and reproduction.

Geographical Distribution of Restoration Projects

In the long-term (>10-years), each ecological zone and ecological unit will likely receive fair consideration for funding and implementation of restoration projects. In the short-term (< 10-years), species status, habitat condition, and potential of restoring or improving ecological processes will dominate the selection process.

The Sacramento-San Joaquin Delta, because of is location and function and the number of proposed restoration actions will receive a high proportion of the restoration effort.

Timelines for Restoration Efforts to Succeed

Some restoration projects can be implemented more quickly than others and the results immediately measured. Other restoration projects may take a decade or longer for the benefits to be apparent. For example, removing a migration barrier to anadromous fish has an immediate observable benefit, while implementing measures to restore a riparian corridor and provide shaded riverine aquatic habitat could take many years for the vegetation to reach the appropriate age structure and compexity. There is much merit in the early implementation of programs that require and extended time to reach maturity.

Restoration Priorities

Priority for Setback Levees and Floodplain Improvement Projects

- Sacramento River-Colusa to Sacramento
- Sacramento-San Joaquin Delta
- San Joaquin River
- Smaller tributaries to Sacramento River.

Priority for Unscreened Diversions

- Sacramento River above Hamilton City to protect winter-run chinook salmon.
- Sacramento River below Hamilton City to protect all anadromous fish that can be protected by screens.
- Sacramento-San Joaquin Delta
- San Joaquin Delta
- San Joaquin tributary streams
- Streams supporting spring-run chinook and steelhead

Priority for Fish Passage

- Mainstem Sacramento River

- Streams supporting spring-run chinook salmon
- Streams supporting steehead

PRIORITY FOR RIPARIAN AND RIVERINE AQUATIC HABITAT RESTORATION

- Mainstem Sacramento River-Red Bluff Diversion Dam to Colusa
- Mainstem Sacramento River-Colusa to Sacramento
- San Joaquin River
- Streams supporting spring-run chinook salmon
- Streams supporting steehead

PRIORITY FOR CONTAMINANTS

- Upper Sacramento River

PRIORITY FOR WATER ACQUISITION

The strategy for water acquisition is a very important part of the ERPP. Water is actively being sought through a variety of other State and federal programs such as the State Water Bank and Central Valley Project Improvement Act. The ERPP strategy is closely linked to these existing programs.

[expand]

PRIORITY FOR LAND ACQUISITION AND CONVERSION TO HABITAT

- North Delta
- Suisun Bay
- East Delta

PRIORITY FOR CONTROL OF INVASIVE ORGANISMS

[In progress.]

PRIORITY FOR SEDIMENT SUPPLY

[In progress.]

PRIORITY FOR TEMPERATURE CONTROL

[In progress.]

PRIORITY FOR HARVEST

[In progress.]

BALANCING IMPLEMENTATION AND FOCUSED RESEARCH

[In progress.]

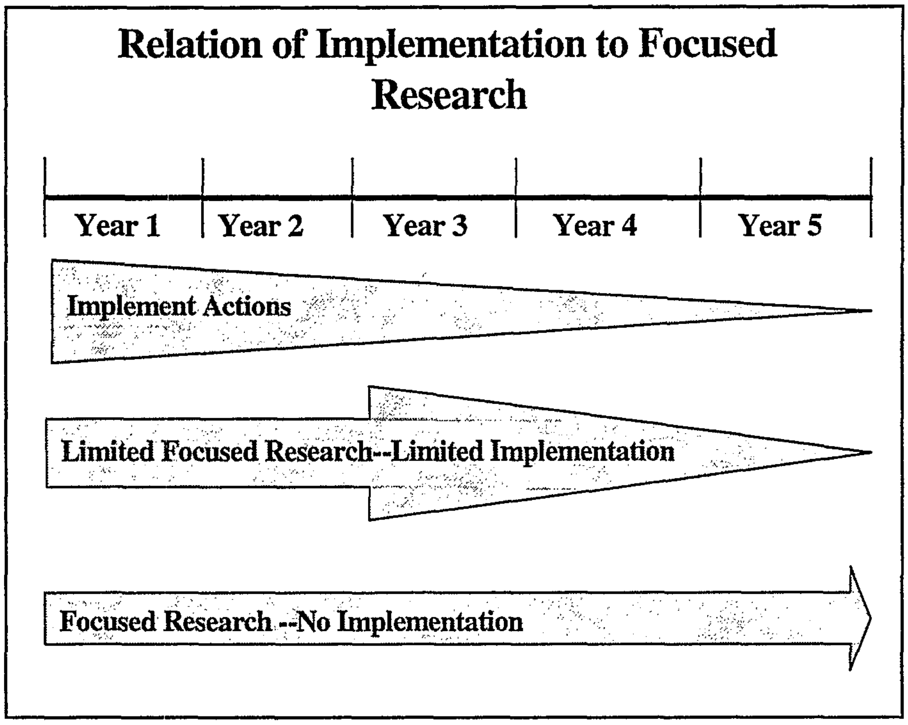
A MULTI-DIMENSIONAL PRIORITY SCHEMES

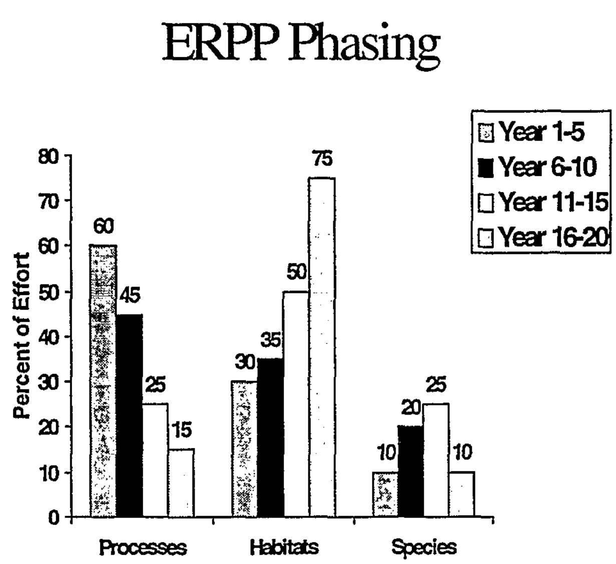
COARSE SCREENING CRITERIA

The initial coarse screening criteria are comprised of the CALFED solution principles. An actions considered for implementation must pass all six tests provided by the principles:

- Does the proposed action reduce conflicts in the system?
- Is the proposed action equitable?
- Is the proposed action affordable?
- Will the proposed action be durable?
- Is the proposed action implementable?
- Will the proposed action have any significant redirected impacts?

A proposed actions fail the coarse screening criteria with a "no" answer to any of the first five questions or yes to the last question.





Category	Implementation Interval (Years)				
	1-5	6-10	11-15	16-20	20-25
Convert Land to Habitat	Medium	Medium	High	High	Medium
Levee Setbacks	Medium	High	High	Medium	Medium
Fish Passage	High	Medium	Medium	Low	Low
Riparian Restoration	High	Medium	Medium	Medium	Medium
Contaminants	Medium	Medium	Medium	Medium	Medium
Water Acquisition	High	High	Medium	Medium	Medium
Land Acquisition	High	High	High	Medium	Medium
Control Invasive Organisms	Medium	Medium	Medium	Medium	Medium
Improve Sediment Supply	High	High	High	Medium	Medium
Improve Stream Temperatures	High	High	Medium	Medium	Low
Improve Harvest Management	Medium	Medium	Medium	Medium	Medium
Unscreened Diversions	High	High	Medium	Medium	Medium
Stream Meander Corridor	High	Medium	Medium	Medium	Medium
Improve Hatchery Operations	Medium	High	High	Medium	Medium
Upper Watershed Support	Low	Medium	Medium	Medium	Medium
South Bay Support	Low	Medium	Medium	Medium	Medium
Nearshore Ocean (harvest)	Medium	Medium	Medium	Medium	Medium

Key	
Level of Effort	Code
High	(solid black)
Medium	(hatched)
Low	(blank)

PHASED IMPLEMENTATION FOR ECOLOGICAL PROCESSES

Ecosystem Element	Implementation Interval (Years)				
Ecological Processes	1-5	6-10	11-15	16-20	20-25
Streamflow	High	High	Medium	Medium	Medium
Sediment Supply	Medium	High	High	Medium	Medium
Meander Corridor	Medium	Medium	High	High	Medium
Floodplains and flood processes	Medium	High	High	High	Medium
Stream Temperatures	High	Medium	Medium	Low	Low
Bay-Delta Hydraulics	High	Medium	Medium	Medium	Medium
Bay-Delta Aquatic Foodweb	Medium	Medium	Medium	Medium	Medium
Upper Watershed Support	Low	Medium	Medium	Medium	Low

Key	
Level of Effort	Code
High	■ (solid)
Medium	(hatched)
Low	(blank)

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PHASED IMPLEMENTATION FOR HABITAT

Ecosystem Element	Implementation Interval (Years)				
Habitat	**1-5**	**6-10**	**11-15**	**16-20**	**20-25**
Tidal Perennial Aquatic	High	High	Medium		
Nontidal Perennial Aquatic		Medium	High	Medium	
Delta Sloughs	Medium	Medium	High	Medium	
Midchannel Islands and Shoals	Medium	High	Medium		
Saline Emergent Wetlands	High	Medium	Medium		
Fresh Emergent Wetlands	Medium	High	Medium		
Seasonal Wetlands			Medium	Medium	
Riparian and Riverine Aquatic	High	High	High	Medium	Medium
Inland Dune Scrub					
Perennial Grasslands		Medium	Medium		
Agricultural Lands	Medium	Medium			

Key	
Level of Effort	Code
High	
Medium	
Low	

PHASED IMPLEMENTATION FOR ECOSYSTEM STRESSORS

Ecosystem Element	Implementation Interval (Years)				
Stressors	1-5	6-10	11-15	16-20	20-25
Water Diversions	High	High	Medium	Medium	Medium
Dam, Reservoirs,...	High	Medium	Medium	Low	Low
Levees, Bridges, Bank Protect	Medium	High	High	Medium	Medium
Dredging and Sediment Disposal	Medium	High	High	Medium	Medium
Gravel mining	High	High	Medium	Low	Low
Invasive Aquatic Plants	Medium	Medium	Medium	Medium	Medium
Invasive Aquatic Organisms	Medium	Medium	Medium	Medium	Medium
Invasive Riparian Plants	Medium	Medium	Medium	Medium	Medium
Non-Native Wildlife	Low	Low	High	Medium	Low
Predation and Competition	Medium	Medium	Low	Low	Low
Contaminants	Medium	Medium	Medium	Medium	Medium
Harvest	High	High	High	Low	Low
Artificial Fish Propagation	High	Medium	High	Low	Low
Disturbance	Medium	High	High	Low	Low

Key	
Level of Effort	Code
High	(solid black)
Medium	(hatched)
Low	(blank)

PHASED IMPLEMENTATION FOR MONITORING AND FOCUSED RESEARCH

Category	Implementation Interval (Years)				
	1-5	6-10	11-15	16-20	20-25
Monitoring					
Focused Research					

Key	
Level of Effort	Code
High	
Medium	
Low	